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# JOURNAL OF INFORMATION SYSTEMS APPLIED RESEARCH

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# Voting System Risk Assessment: A Process Using Threat Trees

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## Abstract

Security continues to be a critical issue in the safe operation of electronic voting machines. Risk assessment is the process of determining if a particular voting system is at risk and what steps can be taken to mitigate the risk. We propose an iterative risk assessment process using threat trees. This process involves using a voting system risk taxonomy to categorize a threat, a schema to express logical hypothesis about a threat, generating a threat tree through functional decomposition, expressing threat instance semantics as nodal properties with metrics, validating the threat instance through independent representations, and finally pruning the tree for enhanced usability and understandability. This process provides guidance to an analyst in using threat trees to conduct risk assessment of electronic voting systems. Because this process is based on abstract and extendable structures, it facilitates the comparison and validation of independent risk evaluations. Prospective voting system risk assessment metrics are provided.

**Keywords:** electronic voting systems, risk assessment, threat trees, taxonomy

### 1. INTRODUCTION

In their 2004 seminal work Kohono, Stubblefield, Rubin and Wallach (2004) et al. closed the book on the question of whether security mechanisms were critical to safe operation of electronic voting machines. Their analysis showed that there were many critical vulnerabilities in a widely used voting system. That work also precipitated a firestorm of vulnerability analyses that further confirmed that existing electronic voting system security mechanisms were insufficient to ensure election integrity.

This paper represents a first step in providing guidance to analysts for systematically determining if particular voting systems are at risk and to identify steps that can mitigate that risk. There is significant work documented in the literature regarding fault analysis (Clifton, 1999) and threat tree analysis (Schneier, 1999; Uppal, 2007; Evans, Heinbuch, Kyle, & Porokowski, 2004), but our work details a specific approach for specifying voting system threats that can facilitate risk analysis.

As information systems go, voting applications are relatively simple. Their core function is to capture the will of the eligible voters. There are no complex algorithms; addition is simple arithmetic and the numbers are relatively small, as computer computations go.

On the other hand, voting systems have been under attack for centuries, with malicious parties trying to influence, or control electoral outcomes. An important challenge to conducting effective elections is to protect against these manipulative threats.

In this paper, we introduce a process for identifying, categorizing, specifying, validating, and pruning voting system threats. At the core of this process is the threat tree.

A threat tree is a data structure for representing the steps that an attacker would take to exploit a vulnerability in order to accomplish malicious intent. While there has recently been much discussion of voting system threats and numerous voting system security vulnerability assessments, (Black Box Voting, 2005); Yasinsac, Wagner, Bishop, Baker, Medeiros, Tyson, Shamos, & Burmester, 2007; Gardner, Yasinsac, Bishop, Kohno, Hartley, Kerski, Gainey, Walega, Hollander, & Gerke, 2007; California Secretary of State, 2007; Epstein, 2007; & Alaska, 2008) we are unaware of any systematic or formal effort to catalog, specify, and validate voting system threat trees.

Threat trees allow the analyst to (1) Descriptively name nodes as threat goals and steps (2) Graphically express logical relationships between nodes and (3) Define attack goal and step semantic properties as nodal attributes. Collectively these three characteristics allow the abstraction and precision that are necessary to reason comparatively about fundamentally different threats.

The remainder of this paper provides a detailed description and discussion of the risk assessment process followed by a brief summary.

## 2. VOTING SYSTEM RISK ASSESSMENT PROCESS

The purpose of the voting system risk assessment process is to provide guidance to an analyst in using threat trees to conduct risk analysis of voting systems. The power of this process derives from the use abstraction to produce artifacts that categorize and illuminate important voting system security issues while facilitating a balance between detail and complexity. These artifacts, because they are based on generalizations that are flexible and extensible yet explicit in their construction, enable an analyst to compare and validate independent evaluations of risk. In other words, these generalizations provide a common structure upon which to express individual perceptions, metrics, and analyses.

The threat tree generation process consists of six iterative steps (see Figure 1). The first step is to identify the threat as a high level attack goal. In the second step, the analyst rigorously defines the high level goal by assigning relevant parameters from the voting system attack taxonomy, creating new taxonomy parameters where necessary. This level of detail provides the foundation for the refinement step that follows.

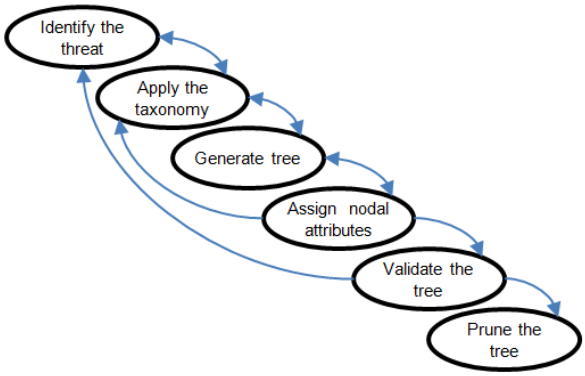


*Figure 1.* Risk Assessment Process.

In the fundamental step of the process, threat tree generation, the analyst conducts functional decomposition, recursively expanding each node into its requisite tasks. The recursive functional decomposition continues until the threat is refined sufficiently to conduct the necessary analysis. The result of this step is a threat tree.

With the threat tree defined, each node is assigned attributes that capture properties that are relevant to the analyst. These attributes may be metrics, data points that allow analysts to compute metrics, or simply observations that provide the analyst a point of reference for their analytical processes. They differ from the taxonomy parameters in that while taxonomy parameters are generic threat properties that allow threat categorization, these attributes are specific to the analyst's risk assessment goals.

In the fifth step, the analyst iterates the first four steps to validate and enhance the threat tree. Each of the first four steps increases specificity, adding detail to the threat processes and properties.

In the final step, the analyst prunes the threat tree through abstraction leaving a threat tree that is well understood and whose threat instances can be comparatively analyzed.

The remainder of this section contains a detailed description of each step in using the voting system risk assessment process.

### 2.1. IDENTIFY THE THREAT

The first step is to identify the high level threat. The analyst may derive high level threats through literature searches, brainstorming, personal experience, newspaper articles, etc. To be most useful, the identified threat's impact must be tangible and measurable. For example, the threat: "Remove a ballot from a ballot box" is concrete while "Change an election result" is inherently ambiguous.

### 2.2. APPLY THE TAXONOMY

The second step of the process requires the analyst to define the high-level threat in abstract yet precise terms. In order for these definitions to be useful in making independent comparisons and analysis, threats must be categorized according to a common structure. We offer a voting system threat taxonomy for this purpose. Our extensible voting system risk taxonomy can capture important properties of voting system vulnerability and those that may seek to create corresponding exploits. This taxonomy employs a hierarchical structure based on attribute n-tuples , where the lower levels comprehensively describe the properties of the parent.

#### 2.2.1. TAXONOMY CLASSIFICATION

Taxonomy fundamentally classifies the target group. That is, it provides commonality among group members in a way that can facilitate understanding and application. For example, our proposed taxonomy provides a mechanism for analysts to more precisely capture the threats that they are expected to analyze. This abstraction may be realized by searching, for example, against attribute wild cards, i.e. all attacks that accomplish wholesale impact, or all attacks that involve rogue poll workers.

These abstractions may allow elections officials to devise procedures that can systematically mitigate the defined threats. For example, preventing voters from accessing removable media eliminates the class of attacks that pairs the following:

<Role(Voter), AttackVector(RemovableMedia)>

Similarly, if the voting system does not include commercial off the shelf software, then all attacks associated with the attribute <Software(COTS)> are eliminated.

Finally, the taxonomy can allow the analyst to identify and syntactically prohibit conflicting attributes. For example, it may not be possible to conduct a DoS attack after the voting period ends. We term these "constraints" in the taxonomy and represent them as predicate pairs, e.g.:

<Objective(DoS), Phase(AfterVotingPeriod)>

One challenge of modeling any process or issue is to decide what level of detail is optimum. Excessive detail can unnecessarily complicate the model, while too little detail can limit its usefulness. Our voting system threat taxonomy's present form is easily extensible. As threat attributes emerge, they may be added to the tree depth or items of less interest may be removed. Moreover, the model can be automated to prompt manual entry guided by the taxonomy's syntax.

The content of the threat taxonomy is based on an extensive review of the extant literature and the experience and expertise of the authors. The taxonomy was constructed in a top-down process where each logical structure block was decomposed into non-overlapping sub-block structures.

We provide our voting system threat taxonomy as Appendix A.

#### 2.2.2. SCHEMA

The voting system risk taxonomy enables the analyst to consistently classify threats through a common syntax. However, the usefulness of the resulting artifacts will be limited if 1) the analyst does not have a means of consistently expressing the logical hypothesis engendered by the definition of an attack and 2) a consistent means of expressing terms contained in those hypothesis. A schema serves both needs.

We generate voting system threat tree definitions and schema by creating logical hypothesis regarding prospective voting system attacks and we capture that hypothesis as n-tuple expressions. For example, we posit, as definition, that the only two overarching voting system attack goals are to either alter or ensure a contest result or to negatively impact voter

confidence. We capture that hypothesis as follows:

VSAttack = <AlterContestDecision, UndermineVoterConfidence>

We similarly posit that there are only four ways that an attacker can alter a contest decision, given as:

AlterContestDecision = <AddVotes, DeleteVotes, FlipVotes, AlterCount>

Further, votes are either physical or electronic, so:

DeleteVotes= <DeleteAcceptedBallotsPhysical, DeleteAcceptedBallotsElectronic>

Finally, we propose the following hypothesis regarding any attacker's ability to delete an accepted physical ballot, stated as a schema:

schema: DeleteAcceptedBallotsPhysical.[Phase].[Control] = <GainPrivateAccessToABPs.

RemoveABPsFromControlledCustody,

MoveABPsToPrivateSpace>

This schema stands as a template or skeleton for any voting system attack that involves deleting physical ballots.

The definitions and schema above reveal the pseudo-formal language approach that we adopt. Our conventions include:

- Use short phrases coupled as long words, with the first letter of each word in caps
- Only abbreviate well known terms or phrases
- Establish a data dictionary of node names

We provide an extended set of definitions and schema as Appendix B.

### 2.3. GENERATE THREAT TREE

Step three involves the recursive functional decomposition of a threat into a collection of goals and steps necessary to carry out a threat. The recursive functional decomposition continues until the threat is refined sufficiently to conduct the necessary analysis. The result of this step is a threat tree.

#### 2.3.1. THREAT TREES

For our purposes, a threat defines the process that one or more attackers might take to accomplish a malicious act in an election. The "tree" is a powerful abstraction that graphically captures relationships among nodes that are hierarchically connected by directional edges, while allowing analysts to express individual node properties as nodal attributes. The tree structure allows a systematic approach to threat analysis, including facilitating abstraction and decomposition and allows analysts to categorize goals and steps so they can focus on those that are most critical.

For threat trees to be most useful, node names must capture the node's core function, whether the node is a goal or a step. Short, succinct names allow the analyst to recognize the collective meaning of the tree based on node type, name, and connectivity.

#### 2.3.2. THREAT TREE COMPONENTS

In order to leverage tree structures to represent threat processes, we define voting system threat trees so that their graphical properties capture important process relationship properties. We accomplish this by establishing the three node types of AND, OR, and TERMINAL . Subordination reflects specification through functional decomposition, so nodes higher in the tree are abstractions of subordinate nodes. All nodes that are immediately subordinate to an AND node must be carried out in order to meet higher level goals, while OR node subordinates reflect alternate means to accomplish an intended function. TERMINAL nodes have no subordinates, thus reflect the primitive operations (i.e. steps) that accomplish the modeled threat, while AND and OR nodes reflect intermediate attack goals. We provide a glossary of terms related to voting system threat trees as Appendix C. Figure 2 illustrates a generic threat tree composed of AND [A, D], OR [B, I], and TERMINAL [C, E, F, G, H, J, K] nodes.

A tree represents many threat instances, or attacks, as a combination of TERMINAL nodes that satisfy the logical requirements of the tree. For example, in order to realize threat A, an attacker would have to carry out goals B, C and D. Accomplishing E, F, or G would accomplish B, while H and J or K would be needed to accomplish D. Thus, <E, C, H, K> is one attack represented in Figure 1, as is <G, C, H, K>. There are four other TERMINAL node (step)

combinations (threat instances) that realize threat A.

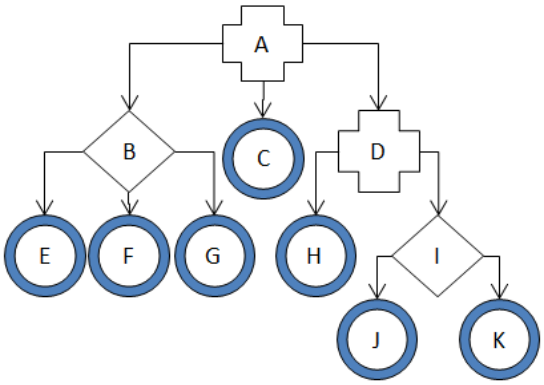


*Figure 2.* Generic Voting System Threat Tree.

We can identify several properties of the threat instances captured in this tree without knowing any of the nodes' semantic properties. We know for example that:

- The tree depth is four and its breadth is seven
- This tree represents exactly six distinct threat instances
- Each threat instance requires four steps (i.e. four TERMINAL nodes)
- Nodes C and H are necessarily steps in every threat instance

These are computations that can be applied to all tree structures and all other routine tree algorithms and provability properties similarly apply to these trees. Thus, we know that splitting a TERMINAL node into an OR node doubles the number of represented distinct attack instances. If the split is an AND node, it adds one step to each attack instance that includes the replaced node. The practical importance of these properties and computations will be evidenced in the validation of threat tree metrics.

We also know that canonical limitations that apply to tree structures also apply to our voting system threat tree, most importantly that their size expands rapidly relative to their breadth and depth. In our approach, tree depth is controlled by the level of detail necessary to describe the goal or activity represented in the node. These decisions are made by the analyst. For example, if a particular threat may involve the task of "Picking a lock", one analyst may encode that task as a TERMINAL node, while another may encode it as an AND node with the subordinate TERMINAL nodes of "Acquire necessary skill and knowledge" AND "Attain Necessary Access" AND "Acquire necessary tools" AND "Pick the lock". The latter approach adds one level of depth to its branch.

Note that we intentionally avoid temporal notions of step or goal sequencing in the tree's graphical representation. If sequencing is important to a specific analysis, temporal dependencies may be expressed as nodal properties.

### 2.4. ASSIGN NODAL PROPERTIES

At this stage in the process, the focus shifts from the syntax of generic threat categorization to the semantics of the primitive operations (steps) of a threat in the context of a specific risk assessment. The analyst must define a threat instance for an attack (a realization of a threat) and assign attributes specific to the threat instance. The two attributes required by our process are likelihood and impact. Likelihood is the probability that an attack will be realized and impact measures the consequences of an attack. Both likelihood and impact are expressed and measured as quantifiable metrics.

#### 2.4.1. THREAT INSTANCE

The unit of evaluation for voting system threat trees is a threat instance, or equivalently, an attack, thus an attack is the realization of a threat. We choose to focus on primitive operations (steps) because steps can be associated with a metric. For example, an analyst can estimate how much or how little of some resource is required to carry out a given set of steps. A goal represents an attacker's purpose or objective. As such, it is more difficult to assign quantifiable metrics to a purpose or objective than it is to a concrete activity or sequence of steps.

Metrics are important because they allow the analyst to compare and validate independent evaluations. This allows the analyst to reason comparatively about fundamentally different threats to voting systems. However, it is not always possible or feasible to provide direct evaluations of all possible sets of primitive operations or steps in a threat tree because of the potential for state space explosion.

We use goal nodes to abstract multiple sets of steps into a single logical unit of evaluation and thus mitigate this problem. Abstraction can reduce tree depth and make evaluation tractable. For example, in Figure 2, if we understood the properties of node I sufficiently to collapse it into a TERMINAL node, thus eliminating nodes J and K, it would reduce the number of threat instances by half (from six to three). Thus, it may make sense to decompose goals in order to reason about them, but where that understanding is sufficiently detailed, to evaluate the tree at a higher abstraction level to reduce the evaluation state space.

### 2.4.2. THREAT INSTANCE METRICS

Threat tree nodes may have many, sometimes seemingly contradictory, properties that dictate or influence a goal or step's occurrence LIKELIHOOD or its potential IMPACT. These are, of course, the two parameters for assessing voting system risk. Voting systems in the United States are highly complex. Consequently, risk LIKELIHOOD and IMPACT are varied and difficult to capture and express. It is not uncommon for two highly qualified election experts to disagree vehemently regarding the voting system risk.

We highlight some voting system threat node attributes that capture a perspective of each of these properties in this section.

#### 2.4.2.1. LIKELIHOOD METRICS

We may measure LIKELIHOOD and IMPACT as a continuous variable on a 0 to 1 scale. For the former, 0 (as the lower LIKELIHOOD extreme) would indicate that the event will not (or cannot) occur, while 1 (at the upper extreme) means that the event is certain to occur. For the latter, 0 would reflect no impact while a catastrophic result would represent the opposite extreme impact. Alternatively, a simple three step discrete metric of high, medium, and low could also represent LIKELIHOOD and/or IMPACT.

The only absolute in estimating risk likelihood is that there are no absolutes. Issues of relativity, temporality, uncertainty, and other qualifications render even the most intuitively accurate assumptions invalid, or worse yet, counterproductive. The best that we can hope for is to leverage heuristics to find metrics that incorporate best practice experience and offer analysts a chance at estimating comparative risk. We offer a few such prospective voting system risk assessment metrics below.

**Cost.** The resource commitment required to carry out a voting system attack always bounds the prospective attacker's options. Money, labor, time, and equipment are canonical resources that are represented in a cost metric.

**Necessary expertise.** We may expect that a requirement for specialized knowledge or skill diminishes the likelihood of an attack occurring. The obvious likelihood limitation is that specialized expertise injects is to reduce the pool of potential attackers or increases the time and resources that an attacker needs to carry out the attack. It also likely indicates that there is an advanced sophistication, and a resulting elevated complexity, in the prospective attack.

**Detectability.** Detection can enable prevention of many types of voting system attacks. It can also allow officials to punish perpetrators after the fact and can allow correction of damage caused by a voting system attack.

We use the term "detectability" to capture the notion of how difficult or likely it is that an attack will be detected. We posit generally that attacks, events, and actions that are more likely to be detected are less likely to be attempted and that they are less likely to achieve maximum impact than those that are more difficult to detect.

#### 2.4.2.2. IMPACT METRICS

Generically, we think of threat IMPACT as the *magnitude or degree of damage* that will, or is expected to, occur as a result of a realized threat. In practice, IMPACT is context exclusive to the extent that the same voting system threat may have a catastrophic impact in one environment, but be essentially benign in a different environment. Assignment of the IMPACT metric is a major and important task of the analyst and requires significant subject matter expertise.

The two primary overarching goals of voting system attacks are either to impact election integrity or to influence public's perception about the election. Thus, we partition IMPACT metrics according to these two aspects and address IMPACT as the magnitude of the effect on voting system integrity or public perception.

#### 2.4.2.3. INTEGRITY IMPACT METRICS

Voting system integrity attacks are what we think of when we discuss election fraud, that is, integrity attacks maliciously influence a contest

result in an election. This encompasses canonical election fraud issues, such as ballot stuffing.

Voting system integrity attack impact ranges from deleting one legal vote (or equivalently, injecting one illegal vote) with no impact on any contest selection, to controlling the selected candidate or issue decision in all contests. Voting system integrity issues are either related to vote counting (process where each voter selection is added to the total, one by one) or aggregation (where subtotals are combined to reflect the cumulative result). The following metrics are illustrative (as opposed to comprehensive) and represent issues that are relevant to risk assessment.

Without knowing a contest result a priori, an attack waged during the voting period has the best chance to be decisive if it can effect a large volume of votes . Such attacks are similar in many ways to wholesale purchasing tactics and the term "wholesale vote fraud" has become part of the election integrity vernacular. Wholesale attacks optimize effort-to-effect ratio, or more mathematically, retail attacks are linear in terms of the effort-to-effect ratio, while wholesale attacks are geometric (or exponential) in effort-to-effect ratio.

Knowing the magnitude of change necessary to control an electoral decision can be important to an attacker, allowing a small number of votes to be decisive. We have recently seen two federal elections (Minnesota Senate 2008 election and New York's 2009 special election for their 20th Congressional district) decided by only a few hundred votes. Each of these contests was vulnerable to post voting period attacks where a relatively small malicious change could be decisive.

#### 2.4.2.4. PUBLIC PERCEPTION IMPACT METRICS

For a malicious party that desires to negatively influence election-related public perception, the prospective damage ranges from generating isolated incidents of misunderstanding to wrongfully creating widespread belief that one or more electoral decisions were influenced by error or malice. While election integrity attacks against voting systems predominantly involve data and processes that are integral to conducting an election, perception issues are uniformly driven through mass information dissemination media that is separate from the voting system. The voting system responsibility in this process is to be able to provide strong, accurate information about election activity. Thus, attacks on public perception are either voting system independent, or involve modifying data reported to public dissemination media, as reflected in the following illustrative metrics.

Elections officials uniformly rely on validation mechanisms both to ensure election integrity and to reassure the public of election accuracy. Virtually all validation mechanisms employ some type of redundancy, so attackers may attack either the primary electoral product or the validation data in order to create a negative perception (Yasinsac & Bishop, 2008). For example, ballot accounting procedures measure the number of ballots issued against the counted. A public perception attack may target the records of the number of ballots issued so that validation will suggest that there were more voters than ballots. The greater the disparity, the greater the potential to create negative public perception.

### 2.4.3. THREAT INSTANCE STOPPING FUNCTION

A challenge to any system based on functional decomposition is how to fashion a stopping function. That is, it can be difficult to identify the best or most effective abstraction level to ensure that the decomposition process does not reach a point of diminishing returns.

In our case, decomposition stops when the analyst can assign values to the nodal attributes with sufficient precision to accomplish the necessary global computations. For example, if our metric is cost, the analyst must decompose the task to the level that the cost of each step is clear and justifiably assigned. Justification may be based on the skill of the analyst or upon some predefined threshold, but the degree of precision is always dictated by the metric's context.

Cumulative analysis must then begin at the TERMINAL nodes that comprise each threat instance, which is our unit of evaluation. To illustrate, we compute the cost (C) of instance (i) of threat (a) as (C(a, i)), which is the sum of the costs of the steps required to carry out threat instance (a, i). For example. if <E, C, H, K> is instance 1 of threat A, as shown in Figure 1 on page 5 above, we compute:

$$C(A,1) = C(E) + C(C) + C(H) + C(K)$$

Thus, the fundamental voting system threat tree unit of evaluation is horizontal. That is, metrics are assigned at the TERMINAL nodes and those values are accumulated by threat instance, which reflects the tree's greatest specificity level and the level where the metric is assigned.

### 2.5. VALIDATE THREAT TREE

Since there are no well known metrics, metric validation is essential to the voting system risk assessment process. One way to approach validation is through comparing independent representations. With voting system threat trees, if metrics have suitable computational properties, we can use redundancy by comparing expert assessment against computed values.

To accomplish this validation, an analyst would employ a five stage analysis.

1. Select a metric that that can be assigned based on expert opinion
2. Create an algorithm for computing a parent node's metric based on the child metric values8.
3. Apply expert metric evaluation rules to every node in the tree
4. Compute the metric value for each goal node and
5. For non-terminal nodes, compare the value assigned in Step 3 to the value that is vertically computed from its subordinate nodes in Step 4.

To illustrate, consider the simple [hypothetical] threat tree in Figure 3 with the nodes:

A: Threaten voting equipment

B: Create malware

C: Install the malware

D: Design attack

E: Gain necessary knowledge

F: Determine sleepover location

G: Gain access to sleepover location at an appropriate time.

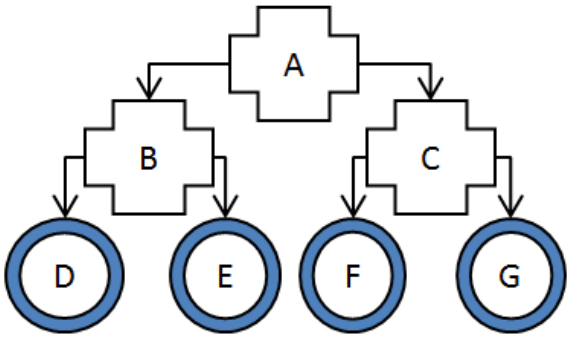


*Figure 3.* Simple, Generic Threat Tree.

We now conduct the five stage analysis:

1. Select cost metric C
2. Compute the cost of a parent as the sum of the cost of the children
3. For instructional purposes, assume that the analyst opinion review assigns the cost of each node to be:

   (1) C(A) = 75, C(B) = 10, C(C) = 100, C(D) = 5, C(E) = 5, C(F) = 50, C(G) = 100
4. We compute the cost of the non-terminal nodes is:

   (2) C(A) = 160, C(B) = 10, C(C) = 150
5. Comparison of evaluations (3) and (4) reveals an inconsistency between the expert analysis and computed analysis at the highest level, which would not be surprising. It also reveals an inconsistency between the expert evaluation at the intermediate level for node C, suggesting reanalysis of assigned values for nodes F and G, or consideration of re-examining node C's decomposition.

### 2.6. PRUNE THREAT TREE

The goal of pruning the threat tree is to strike a balance between abstraction and detail. The tree must have sufficient detail to be useful and understandable by the analyst. However, too much detail creates a model that is unnecessarily complex. Complexity creates excessive cognitive load for the analyst (reducing understandability) while potentially make quantitative analysis of the tree's metrics intractable (reducing usefulness).

For example, in the simplified threat tree depicted in Figure 2, assume that step E (Gain necessary knowledge) was originally decomposed into two additional OR steps: "H: Interview insider" OR "I: Review software components". Perhaps the analyst constructing the threat tree, after validating the tree's metrics, determined that considering whether the attacker interviewed a vendor employee OR obtained a copy of a software component for private review was extraneous to understanding the likelihood and impact of the attack. Therefore, to reduce the complexity of the tree, make the tree more understandable and usable, these two steps were pruned from the threat tree.

## 3. SUMMARY

In this paper, we propose a voting system risk assessment process that leverages three characteristics of threat trees: the ability to (1) Descriptively name nodes as threat goals and steps (2) Graphically express logical relationships between nodes and (3) Define attack goal and step semantic properties as nodal attributes. Collectively these three characteristics allow the abstraction and precision that are necessary to reason comparatively about fundamentally different threats.

The provision of a voting system risk taxonomy and schema facilitates the comparison and validation of independent risk evaluations. That is, because the taxonomy provides a common syntax for categorizing threats and the schema provides a means of expressing logical hypothesis in consistent terms, the risk assessment of independent analysts can be compared in a logical and quantifiable manner. Further, because this process is based on abstract, extendable and common structures, it can be effective for facilitating group risk assessment. Rather than comparing independent risk evaluations after the fact, analysts can work collectively through each phase of the process.

Future research should include a vetting or validation of the schema and taxonomy by voting systems domain experts.

## 4. ACKNOWLEDGEMENT

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**Editor's Note:**

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**Appendix A. Voting System Threat Taxonomy**

VSRisk = <Attack, Impact, Likelihood>
- Impact = <Magnitude**,** ContestBreadth, NumberOfContests**,** Persistence>
  - Magnitude = <**Retail, Wholesale**, CloseRace>
  - ContestBreadth = <**Federal, State, Local**>
  - NumberOfContests = <**SingleContest, MultipleArbitraryContests, MultipleContestsOfGivenType**>
  - Persistence = <**SingleElection, MultipleCycles, Perpetual**>
- Likelihood = <**Low, VeryLow, UnMeasurable, UnImaginable**>
- Attack = <VS, Command, VSRiskTo, Environment, Protocol, MaliciousIntruder+>
  - VS = <PCOS, CCOS, VBM, VBP, DRE, PBHC, IV, BMD>
  - Command = <Adjustable, Precision>
    - Adjustable = <**ChangeOnDemand, LimitedChange, FireAndForget**>
    - Precision = <**Candidate, Contest, Party**>
  - VSRiskTo = <ElectionAccuracy, VoteAttribution, VoterConfidence>
    - ElectionAccuracy = <**VoteError, AccumulationError**>
    - VoteAttribution = <**VoteBuying, VoteSelling, VoterCoersion**>
  - Environment = <Vulnerability, Phase>
    - Vulnerability = <Software**, Hardware**>
      - Software = <**VendorFirmware, COTS,** ElectionDefinition>
      - ElectionDefinition = <**BallotDef, ConfigItems**>
    - Phase = <**BeforePollsOpen, DuringVoting, AfterPollsClose**>
  - Protocol = <Objective+, AttackVector+, **Tree**>
    - Objective = <ChangeCount, **DoS,** VoteAttribution**,** DiscreditCount>
      - ChangeCount = <**BallotStuffing, BallotDeletion, VoteFlipping**>
      - VoteAttributionPurpose = <**VoteBuying, VoteSelling, VoterCoersion, GeneralIrritation**>
      - DiscreditCount = <**CountAuditMismatch, PublicAnomaly**>
    - AttackVector = <**VoterInput, SupervisorEntryDevice, RemovableMedia, Network, VendorKey**>
  - MaliciousIntruder = <Role, Skills, **Resources**>
    - Role = <**Voter, PollWorker, Auditor,** ElectionsOfficial, **OfficeAdmin>**
    - ElectionsOfficial = <Permanent, Temp>
    - Permanent = <**County, State, Vendor**>
    - Temp = <**CountyOffice, Precinct**>
    - Skills = <**HighTech, TechFamiliar, SpecificSkills, TechNovice**>

**Appendix B. Voting System Threat Tree Schema**

VSAttack = <AlterContestDecision, UndermineVoterConfidence>
- AlterContestDecision = <AddVotes, DeleteVotes, FlipVotes, AlterCount>
- UndermineVoterConfidence = <AlterAuditData, AlterContestTotals, DenialOfService, CreateOperationalProblems>
- DeleteVotes = <DeleteAcceptedBallotsPhysical, DeleteAcceptedBallotsElectronic>
- AddVotes = <StuffPhysicalBallotBox, CreateBallotImages>

schema: DeleteAcceptedBallotsPhysical.[Phase].[Control] =
- GainPrivateAccessToABPs
- RemoveABPsFromControlledCustody
- MoveABPsToPrivateSpace

DeleteAcceptedBallotsPhysical.[Phase:AVP].[Control:none] =
- GainPrivateAccessToABPs
- PollWorkerAutomatic or ElectionsOfficialAutomatic or TriggerPollingPlaceFireAlarm
- RemoveABPsFromControlledCustody
- StealBallotBox or RemoveBallotsFromBox
- ConcealContraband
- MoveABPsToPrivateSpace

DeleteAcceptedBallotsPhysical.[Phase:AVP].[Control:AcceptedBallotCoC] =
- GainPrivateAccessToABPs,
- PollWorkerAutomatic or ElectionsOfficialAutomatic or TriggerPollingPlaceFireAlarm,
- RemoveABPsFromControlledCustody(Constraint(RiskCoCDetection)),
- MoveABPToPrivateSpace

Schema: DeleteAcceptedBallotsElectronic.[Phase].[Control].[HackVector]
- Phase = <BVP, DVP, AVP, DR>
- HackVector = <Malware, SupervisorMode, BadData, NetHack, RemovableMediaHack>
- Control = <CommonControl, EControl, PControl>
  - CommonControl = <RandomAudit, PollWatchers, TwoPersonIntergrity>
  - EControl = <L&STest, EquipCoC, ParallelTesting, HashCodeTest>
  - PControl = <VotableBallotCoC, AcceptedBallotCoC, BallotAccounting, BallotWatermarking>

DeleteAcceptedBallotsElectronic.[Phase:Any].[Control:none].[HackVector:Malware] =
- CreateMalware, InstallMalware

DeleteAcceptedBallotsElectronic.[Phase:DVP].[Control:none].[HackVector:Malware] =
- CreateMalware(BVP, DVP), InstallMalware(BVP, DVP)

DeleteAcceptedBallotsElectronic.[Phase:DVP].[Control:L&ATest].[HackVector:Malware] =
- CreateMalware, InstallMalware(Constraint(DefeatL&A or InstallAfterL&A))

## Appendix C. Voting System Threat Terminology

1. **Attack**. The specific actions that one or more attackers might take to accomplish a malicious act in an election. Every attack represented in a threat tree is a threat instance or, equivalently, a threat realization.
2. **Branch**. In a tree, a collection of connected nodes and their edges.
3. **Directed (Edge or Graph).** A directed edge is a non-symmetric edge that reflect some type of ordering. Directed graphs employ only directed edges.
4. **Edge**. Connection between two nodes.
5. **Goal**. A inner node of a threat tree, i.e. a node that has subordinate nodes.
6. **Node**. A component of a voting system threat tree that represents a goal or step in a voting system attack. In our model, there are three node types: AND, OR, and TERMINAL.
7. **Path**. A set of nodes and edges that connect two nodes in a graph.
8. **Step**. A TERMINAL or leaf node that represents a single act or event in a voting system attack.
9. **Threat.** The process that one or more attackers might take to accomplish a malicious act in an election.
10. **Threat Instance**. A set of TERMINAL nodes that collectively satisfy all logical requirements of the threat tree. Every threat instance represents a specific prospective attack.
11. **Threat Tree**. A tree whose nodes represent goals and steps in voting system attacks.
12. **Tree**. For our purposes, a tree is a directed acyclic graph where each node may have two or more children and at most one parent node.
13. **Voting System**. Equipment (including hardware, firmware, and software), materials, and documentation used to define elections and ballot styles, configure voting equipment, identify and validate voting equipment configurations, perform logic and accuracy tests, activate ballots, capture votes, count votes, reconcile ballots needing special treatment, generate reports, transmit election data, archive election data, and audit elections.

# Development of an Evaluation Model for XBRL-enabled Tools Intended for Investors

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## Abstract

As the first decade of the new millennium draws to a close, individual investors will find that a new era in financial analysis is beginning. The United States Securities and Exchange Commission (SEC) now requires corporations to use eXtensible Business Reporting Language (XBRL) when submitting their disclosure filings. XBRL has been developed by an international nonprofit consortium to meet corporate reporting needs. XBRL documents will be made available to the public as soon as they are filed. XBRL-enabled financial analysis tools will enable investors to perform their financial analysis more quickly and accurately. It is now time to consider the needs of financial information stakeholders who will use the information contained in XBRL instance documents. The SEC is encouraging software developers to create XBRL-enabled tools to meet the needs of individual investors and other financial information stakeholders. This paper proposes an evaluation model for reviewing XBRL-enabled financial analysis tools to be used by individual investors. Four freely available XBRL viewers were examined using the evaluation model. The SEC's currently available tool was evaluated in detail to better demonstrate the use of the model. To place this evaluation model in its proper context, this paper examines what XBRL is and how it will contribute to financial analysis. The SEC's XBRL tool is then evaluated in detail in light of the model and suggestions are made for how future tools can be developed to fill the needs of individual investors.

**Keywords:** XBRL, XBRL viewers, XML, evaluation rubric

### 1. IMPORTANT INFORMATION

A new era in financial reporting and analysis is just beginning. The work of hundreds of people over the past decade is coming to fruition as the United States Securities and Exchange Commission (SEC) begins requiring corporations

to use eXtensible Business Reporting Language (XBRL) when submitting their disclosure filings. Individual investors will benefit from the new system that will allow them to access financial information more quickly and analyze the data with tools similar to those used by professional analysts.

The SEC developed its new Next-Generation Electronic Data Gathering Analysis and Retrieval (EDGAR) System to make XBRL filings immediately available to all financial information stakeholders such as individual investors, institutional investors, professional analysts, regulators, creditors, auditors, media analysts and commentators, and anyone else interested in the information. The new EDGAR system "marks the SEC's transition from collecting forms and documents to making the information itself freely available to investors to give them better and more up-to-date financial disclosure in a form they can readily use" (SEC, 2008b, ¶p. 2).

The proponents of XBRL and interactive data have promised many wondrous things for the future of financial analysis. While documents in XBRL format can be easily read by humans, they are optimized for use by computer programs for data retrieval. XBRL-enabled tools, such as XBRL viewers, will provide the ability to gather and analyze data more quickly than currently available methods. The power and promise of XBRL are found in the ways that software applications will be able to read, manipulate, and use XBRL documents data.

The purpose of this paper is to develop an evaluation rubric to examine XBRL-enabled tools and then use the rubric to evaluate the SEC's currently available XBRL tool in relation to individual investors' needs. No published research was found that evaluated XBRL software or the anticipated benefits to be gained by individual investors by using interactive data. Through this research, the authors hope to provide an evaluation rubric for examining XBRL tools, begin the process of evaluating XBRL software, and focus attention on the XBRL tool requirements of individual investors.

## 2. XBRL

In defining XBRL, EDGAROnline (2006) noted, "Think of XBRL as bar coding for financial statements. Every piece of data is linked to explanatory information. You don't just get numbers; you get context (p4)." Labels, or "tags" as they are called in XBRL, provide a variety of metadata, or information about the data. This metadata includes data identifiers, financial statement relationships, the year and quarter for which the data pertain, the currency unit, and other descriptive information (Pryde, 2008). Tags tell any computer application that reads XBRL documents what each data item is so that the application can then use or disregard that item depending on what is trying to be accomplished.

Figure 1 illustrates examples of two tagged items from the Adobe Systems August 28, 2009, 10-Q filing. The XBRL example shows that Adobe is using the United States Generally Accepted Accounting Principles (US-GAAP) taxonomy to show the number of treasury shares and their value in United States dollars (USD) on August 28, 2009. "Decimals=-3" means that the XBRL tool does not show the last three digits because elsewhere, it is stated that the numbers shown on the consolidated balance sheet are in thousands.

```
<us-gaap:TresuryStockShares
contextRef="BalanceAs
Of_28Aug2009"
unitRef="Shares"decimals="-3>
76169000</us-gaap:TreasuryStockShares>

<us-gaap:TresuryStockValue
contextRef="BalanceAs
Of_28Aug2009" unitRef="USD"decimals="-
3>
2962530000</us-gaap:TreasuryStockValue>
```

**Figure 1. XBRL example from Adobe Systems August 28, 2009 10-Q filing**

An XBRL filing with the SEC consists of several files. In addition to the instance document which contains the company's financial information, other files contain information about the taxonomy used, a style sheet describing how the information should be displayed, and files linking various parts of the instance document to online specifications.

In the United States, the XBRL metadata is standardized to correspond to US-GAAP. These tagging standards are known as taxonomies and have been developed for general business reporting as well as for individual industries. XBRL International, a nonprofit consortium of over 500 organizations worldwide working to create and promote XBRL, approved the US-GAAP taxonomies on August 31, 2008 (XBRL International, 2008). The commercial and industrial taxonomy applies to the majority of

corporations while banking and savings institutions and insurance industries have their own industry-specific taxonomies. The taxonomies standardize individual financial elements allowing investors to compare the same financial elements between companies and across industries.

XBRL is also being developed for use around the world using taxonomies based on International Financial Reporting Standards (IFRS) and other national accounting standards. One instance document can be used by multiple applications all looking for different information. One of the truly compelling properties of XBRL is that multinational corporations can produce an instance document of their financial information and submit that document to the regulatory organizations of different countries. Each organization's computer applications will pull the exact information it needs and ignore the rest. The multinational corporation will not have to spend resources recreating financial information presentations for each regulatory specification.

## 3. INTERACTIVE DATA AND FINANCIAL ANALYSIS

The financial scandals of the last decade have highlighted the dangers of financial information that is hidden or obscured by accounting mumbo-jumbo. The Sarbanes-Oxley Act attempted to correct these problems by requiring corporations to provide more comprehensive financial information. When it comes to financial information, investors, analysts, bankers, and regulators all agree that more information is better (McClure, 2008). XBRL can assist with this undertaking by making the financial information so easily available that investors will be able to keep a closer eye on the financial condition of corporations.

Currently, investors have to spend many hours collecting financial information because it is located in different places and formats. While the efficient operation of the equities market demands information, the information itself can be difficult to acquire and use. Bloomfield (2002) noted that "While public data are often free, it takes time and effort to extract statistics even as widely publicized as earnings growth…" (p. 234).

Caplan (2006) describes the information acquisition process as repetitive, time consuming, and error prone. Whatever the source of financial information, someone usually has to rekey the information into spreadsheets or other analysis software for analysis. This process introduces errors, since human beings are prone to making data entry errors (Clarity Systems, 2008). One case study described in Microsoft documentation reported data collection and entry into analysis spreadsheets taking two to six hours for a single target company (Renck, 2005, pp. 3-4).

Bloomfield (2002) pointed out that "…no statistic is relied upon by all traders, not even an earnings announcement." Different investors need different pieces of information and the current sources of information, whether printed, electronic, or web-based, can make the desired information difficult to find. This, in turn, affects the efficiency of the financial markets. Bloomfield developed the Incomplete Revelation Hypothesis and formalized this observation.

XBRL reduces the time and effort to find specific information. Hodge, Kennedy, and Maines (2004) found that XBRL facilitated search capabilities in analysis software that assisted users in finding the information they wanted. The two to six hour process mentioned previously in the Microsoft case study was reduced to a few minutes using XBRL (Renck, 2005). XBRL eliminates the need to rekey information since analysis software will be able to read the information directly from the instance document. Thus, "XBRL improves investor and analyst access to a company's financial information, thereby lowering their uncertainty over perceived risks of investing and providing them with credible, reliable information (Watson, McGuire, & Cohen, 2000).

Professional investors have benefited from being able to access costly data aggregation services and sophisticated investment software tools. The SEC is encouraging software developers to create new XBRL-enabled software applications aimed at individual investors to give them the same kind of tools the professionals have been using. Individual investors use less sophisticated valuation models and do not have well-developed methods for analyzing financial information (Frederickson & Miller 2004; Hunton & McEwen 1997). With better tools, individual investors can participate on a more informed level with professional investors.

## 4. EDGAR

The SEC has developed the Next-Generation EDGAR system as an information portal to enable user-friendly access to the financial data it collects from public corporations operating in the

United States (Securities and Exchange Commission, 2008a). The EDGAR system is a storehouse of corporate reports and forms in text, html, and PDF data formats. Finding a particular financial fact is time consuming since the researcher has to locate the exact document containing the fact and then find the fact within the document.

XBRL documents in EDGAR will allow researchers to automatically search for particular information without having to know exactly which document contains the wanted information. According to former SEC Chairman, Christopher Cox, EDGAR's purpose is to make the information contained in the required financial filings of corporations more readily accessible and give investors "better and more up-to-date financial disclosure in a form they can readily use" (SEC, 2008b). Since 2005, over 100 United States corporations participated in the SEC voluntary filer program by submitting at least one annual or quarterly financial filing using the system. (SEC, 2008a) On December 18, 2008, the SEC approved a new rule requiring corporations with capitalizations of over five billion dollars to supplement their currently required annual and quarterly reports with interactive data starting June 15, 2009. By December 31, 2011, all corporations, required to file with the SEC, will submit their reports in XBRL format according to the phase-in schedule set forth in the new rule (SEC, 2008b).

## 5. LITERATURE REVIEW

Most studies and articles published about XBRL have addressed implementation of XBRL in the accounting and reporting functions (Pinsker & Li, 2008). One barrier to ongoing research has been the lack of tagged financial information and XBRL-compatible software tools. Research into the use of interactive data is just beginning to emerge as government entities around the world start to require the use of XBRL. The SEC in the United States is just the latest overseeing body to mandate filings in XBRL format. Government and regulatory organizations in Singapore, Hong Kong, Spain, and the Netherlands, as well as the FDIC in the U.S., have been collecting information in XBRL format for several years.

A study by Hodge et al. (2004) explored whether a search-facilitating technology improved the transparency of financial reports. The study suggested that technology such as XBRL and related analysis tools could mitigate the problems that inhibit investors from using all available financial information.

### Update Frequency

Pinsker (2007) put forth several research propositions concerning XBRL enabled continuous disclosure, i.e., the ability by organizations to release financial information to outside stakeholders as it becomes available inside the organization. The current financial analysis system is based on quarterly and annual reporting of financial information. If information was available monthly or even weekly, the ability of the marketplace to respond to the increased flow of information would need to be examined.

### Tools

Pinsker and Wheeler (2009) used XBRL documents, that had been submitted to the SEC's voluntary filing program, along with an online XBRL viewer demonstration tool (which is no longer available), to examine "how initial XBRL use affect[ed] subsequent XBRL perceptions" (2009, p. 242). They found that the subjects who used the online viewer "[had] higher perceptions of analytical effectiveness and efficiency through the use of XBRL-enabled information" (p. 255). One interesting finding of the study was that both subject groups had been exposed to a demonstration of the online viewer demonstration and even the paper-based information subject group perceived XBRL to be advantageous for both preparers and users of financial information. In the short time between the Hodge, et al. (2004) study and the Pinsker & Wheeler (2009) study, tagged information became available through the SEC's voluntary XBRL filing program and XBRL demonstration tools were made available for educating investors in using XBRL.

### Use

Other research into XBRL examined issues that could arise with XBRL adoption and proposed possible future extended research. The Working Party of the AAA Information Systems (2005) considered the issues raised by the SEC requiring the use of XBRL in financial reporting. The paper raised several questions about the appropriateness of using XBRL, including concerns about the XBRL taxonomies, whether XBRL would be useful to investors, and the impact of XBRL on SEC filings. In relation to individual investors, the Working Party suggested research could be conducted into how sections of the Sarbanes-Oxley Act could be implemented efficiently using XBRL format, as well as the impact on timeliness of XBRL information.

**Refinement**

Problems with using XBRL for SEC filings are beginning to be identified and studied. Bartley, Chen, and Taylor (2009) compared XBRL filings with the equivalent HTML or ASCII text documents filed with the SEC in 2006. They found numerous errors in the XBRL filings and discrepancies when compared to the official HTML or ASCII text documents. The causes of many of the problems were traced to problems with XBRL tagging software that have since been resolved by software developers. The study also found many errors due to the companies extending the taxonomy with their own definitions. Clearly, experience with and improvements in tagging data would solve many of the problems found in the Bartley et al. (2009) study.

## 6. EVALUATION RUBRIC

In researching for this study, no evaluation matrices for assessing XBRL or XML end-user software were found. Investors are unlikely to use interactive data if they do not understand how to use the viewing technology nor understand how interactive data will benefit them. Thus, software developers need to know what functionality will benefit individual investors in utilizing their XBRL software.

To understand the characteristics that are important to end users, other software evaluation matrices were examined. However, the wide variety of user needs also precludes the development of a standard evaluation model for even one category of software (Perera & Costa, 2008). Thus, future evaluators will be able to use this model as a starting point for developing their specific matrices. Although Stamelos et al.'s (2000) Expert System for Software Evaluation (ESSE) model was examined in light of the current XBRL research project, due to its comprehensive nature, the ESSE was not suitable for this study. The ESSE is an inclusive model for the purchase of an entire computer system including networking hardware and software, training, and support. The ESSE attributes that are specific to software evaluation were too few to apply to the current research project.

The model developed in this research study was based on the Revised Richards-Brown CD-ROM Software Evaluation Model (RRBM) (Figure 2) as outlined in Richards (1995).

CD-ROM retrieval software evaluation was very important in the early 1990s as information providers began to sell or lease CD-ROM resources to libraries. The large databases required special software to access, format, and display or output that information much like today's XBRL viewer tools access, format, and display or output the information contained in XBRL instance documents.

| | |
|---|---|
| **Top Level** | **80** |
| User guidance | 8 |
| Indexing | 10 |
| Search features | 37 |
| General output features | 12 |
| Record display | 10 |
| Database management | 3 |
| **Operational** | **4** |
| **Navigation** | **6** |
| **Ergonomics** | **10** |
| **Total** | **100** |

**Figure 2. Revised Richards-Brown CD-ROM Software Evaluation Model**

The RRBM is a compensatory model allowing the higher scores of certain attributes to compensate for the lower scores of other attributes. It is broken down into four main areas, referred to as variables, which are further broken down into specific criteria. The number of points allocated to each main attribute provides a self-weighting model with more important attributes assigned a greater number of points. A rating of poor, satisfactory, or good is assigned based upon the accumulated total number of points.

While many of the CD-ROM software criteria do not apply to an evaluation of XBRL tools, the methodology and organization of the CD-ROM model has provided a workable framework. The evaluation rubric developed from this framework is entitled "Investor Tool Evaluation Model" (ITEM).

ITEM uses RRBM's compensatory, self-weighting model divided into four main variables (Appendix A). Variables that applied specifically to CD-ROM retrieval software "Top Level" and "Ergonomics" were replaced with the variables "Interactivity" and "Analysis Function" which are unique to XBRL tools. They reflect the promises made by XBRL promoters when describing the potential abilities of XBRL for financial analysis. The criteria in the "general operation" and "guidance" variables have been modified to reflect the

expectations and needs of individual investors who are just beginning to learn about XBRL.

The points available for each attribute are assigned according to how well or how easily the XBRL tool carries out the indicated function. Unless there is a problem with a tool's particular performance of an attribute, the maximum number of points for each attribute will be given. While it is possible to describe each of the evaluative items, only broad guidelines could be provided for assigning specific scores when examining a tool as individual perceptions play a major role in assigning scores.

The point distribution of the rubric reflects the importance of the main variables, "Interactivity" (50 points) and "General Operations" (24 points). Due to its composition of attributes not currently represented in XBRL tools, the variable "Analysis Functions" received only 10 points "Guidance," the last main variable was defined by only two criteria and was allocated 16 points. A brief overview of the definition of the variables follows.

**Interactivity**

Interactivity describes the ability to manipulate and use the information in ways that the user specifies. Interactivity distinguishes interactive data from the traditional, static information that individual investors currently use.

Interactivity was measured by the following attributes:

- **Searching** – searching for terms.
- **Exporting to spreadsheets and other data formats** – the ability to export rather than rekey data.
- **Comparing data** – the ability to compare data between reporting periods and across companies.
- **Context** –information provided to explain data elements.
- **Taxonomy** – definition of elements used in the XBRL document and relationships between elements.

**Analysis Functions**

Because the attributes it evaluates are not well supported in current XBRL tools, Analysis Functions was allocated fewer overall points.

- **Liquidity, profitability, other common investment ratios** – The number of useful ratios available to investors.
- **User defined calculations** – The ability for users to define their own calculations.
- **Charting** – The ability to provide interactive charts for user selected data.

**General Operation**

This variable makes up twenty-eight percent of the evaluation points and has four attributes:

- **Ease of installation** – How easy the software is to install.
- **Terminology** – The amount of XBRL terminology used with less being better.
- **Design of the interface** – Screen design, readability, and accessibility.
- **Open company filing** – Automation level for finding and opening the appropriate SEC filing.

All four constructs are important to the first impression developed by the individual investor for the XBRL tool. User perceptions are involved, thus a zero base point system was followed. Web based tools receive full points. Except for "ease of installation," investors continue to experience these constructs every time they use the software. In these categories, specific situations that warrant zero base points (from the user's perspective) are stated. Individual investors do not have the information technology support that is available to professional analysts so the easier an XBRL viewer tool is to install and operate, the more likely an investor is to use the tool.

**Guidance**

The variable "Guidance" examines the help, instructional, and tutorial materials included with the software. Since XBRL is a relatively new technology, instructions and help information are very valuable to users learning to use interactive data to analyze financial data.

- **Help** – The value and accessibility of the help function and the help content it provides.
- **User manual and/or tutorial** – Print and/or online resources available to assist users.

**Ratings**

The ratings of "poor," "satisfactory" and "good" were based on the total number of points received by each tool for each of the variables, and associated variable constructs, of the model. The score of each area was determined by using

the point guide in Table 1, as adapted from the RRB (Richards, 1995).

| Evaluation Point Guide | | | |
|---|---|---|---|
| **Item** | **Poor** | **Average** | **Good** |
| Interactivity | 0-10 | 11-30 | 31-50 |
| Analysis Function | 0-4 | 5-8 | 9-10 |
| Gen. Operation | 0-7 | 8-17 | 18-24 |
| Guidance | 0-3 | 4-8 | 9-16 |
| Total | 0-24 | 25-63 | 64-100 |

Table-1. Evaluation Point Guide

In the next section, the value of the ITEM rubric will be tested by evaluating the SEC's Interactive Financial Report Viewer.

## 7. APPLICATION OF ITEM TO SEC'S VIEWER

The focus of software development companies has been on developing XBRL tools to produce and verify XBRL instance documents. Software to consume the instance documents has been developed to help verify the accuracy of the instance documents. The needs of other users of the information contained in XBRL documents have not been addressed directly. Of the twenty-two companies listed on the XBRL International website as being involved in the "creation and validation" of XBRL documents, only nine were listed as also providing XBRL viewers, mostly as components to XBRL authoring application suites. There were no companies listed as only providing XBRL viewer tools (XBRL International, 2008). In this section, we apply the rubric to the SEC viewer and present the evaluation results.

### SEC Interactive Financial Report Viewer

Because the SEC has been a strong proponent of the XBRL initiative, their tool was used to evaluate the ITEM rubric. The SEC's web-based viewer was developed for the SEC's 2005 Voluntary Financial Reporting Program to introduce XBRL and interactive data (SEC, 2007). The current version of the viewer was introduced in June 2009 and can be used to view filings submitted to the SEC as soon as they are filed.

To analyze the ITEM rubric, the SEC Interactive Viewer was examined in greater detail. Because this viewer was provided by the SEC, it was used to evaluate the model. The following section describes the scoring results for the individual variables for the SEC viewer.

### Interactivity

Although the SEC has pushed for interactive data, its own viewer had very little interactivity (rating of 17 points) to demonstrate. A user could print one or all of the financial statements and the entire filing could be exported to an Excel file format, however, the viewer did not export to any other formats.

The XBRL context of each item was available in a pop-up box when a user's pointer hovered over a line item, but the viewer did not provide a way to look at the taxonomy used for the filing. There was no search capability or any way to compare data between reporting periods or with other companies.

### General Operations

General Operations received a score of 20 out of 24 points. The display of statements was clean and uncluttered. Alternating blue and white formatted bands made the statement easy to read. No XBRL terminology was used and investors should find it easy to navigate between statements, print out statements, or export the data in an Excel file format to be read by compatible software.

While looking at a specific filing, filings from other periods or companies could not be viewed without exiting the viewer and returning to the "company search" page. This was a negative change from the previous version of the viewer which had a listing of available filings on the left side of the window.

The filing list on the SEC site did not show the XBRL filings submitted under the voluntary filing program. To find XBRL documents that were submitted before May 2009, an investor had to find the voluntary filing viewer webpage.

Viewing notes to the statements was another problem. If the company submitted notes in HTML format, the viewer would show the entire HTML markup. The markup made the note almost impossible to read since the note was shown as an unformatted text file with the HTML and note text in one big block of text and the tables unformatted.

### Analysis Functions and Guidance

The SEC did not provide any help option in the viewer, nor did it have any instructions or tutorial for using the viewer on its website. Thus, the ITEM scoring rubric gave the SEC viewer a score of "0" for both Analysis Functions

and Guidance. There was general information about EDGAR, the filing procedure, and types of documents that were filed, but there were no instructions for the viewer. Although the viewer was generally self-explanatory and easy to use without instructions, a little information might be helpful to investors who will be using the viewer for the first time.

**Observation from Evaluation Results**

When focusing on the individual investor, it was clear that the current version of the SEC's XBRL tool did not meet users' needs nor embody the vision of interactive data that XBRL proponents have advocated. The SEC's free web-based tool provided a non-threatening interface which was simple to navigate and required the users to know little to nothing about XBRL terminology. The viewer provided an easy means for displaying the financial information in traditional financial statement format and for transferring the data into spreadsheet programs. The one drawback of the software was that the user had to navigate through the SEC website first in order to find the tool and filing.

## 8. APPLICATIONS TO OTHER VIEWERS

In the previous section, we presented an elaborate evaluation for the application of the SEC viewer. In order to illustrate the use of the rubric, we chose four lesser known viewers. We present the summary results only (for want of space) for these viewers in this section.

In choosing the other viewers for this study, an "elimination by aspects" (EBA) decision model (Anderson, 1990) was used. EBA was easy to use and provided a quick elimination determination when the minimum criteria were not met. The minimum criteria used for this research project were: 1) easy to find using Google or Yahoo! search engines, 2) free or free trial period, and 3) the online tool worked or the desktop-based tool downloaded and installed. Some online tools that were at the top of the search results were found to be fee-only services without free-trial periods.

Several other tools were found to be components of XBRL software suites and not available separately. Then, there were the tools that were online, but didn't work or were desktop-based but the software download did not work. Four XBRL tools made it past the EBA and were chosen for this study: SEC Viewer, Bowne Viewer, Dragon View, and Xinba 2.0. The total point scores for all four viewers fell far from garnering the full number of points possible with each receiving 37, 46, 23, and 19 respectively. The point breakdown for each of the viewers can be examined in Appendix B.

## 9. CONCLUSION

In this paper, XBRL was described as well as its potential use by individual investors. The authors then developed an evaluation rubric (ITEM) patterned after the Revised Richards-Brown CD-ROM Software Evaluation Model (RRBM) to examine XBRL viewer software. ITEM was then used to evaluate four XBRL viewers that were freely available for individual investors to download and use. The SEC's XBRL viewer was then used to more closely evaluate the rubric.

The XBRL-enabled tool (SEC Interactive Viewer), examined in detail in this paper, serves its users for information display and a conduit for transferring financial information from XBRL instance documents to spreadsheet applications so investors can perform their financial analyses. Providing support for analysis functions within the XBRL tool itself could replace use of spreadsheets and lead to other creative ways of analyzing financial data.

The one attribute not addressed by the model was the handling of notes to financial statements. Notes are an important part of financial statements in that they often contain obscured disclosures of important information which corporate management wishes would go unnoticed. XBRL tools with search capabilities will help bring the obscured information in notes to light so that financial wrongdoings, such as those by Enron and Worldcom, may be harder to bury in the future. ITEM will need to be refined to include note handling once the standards for tagging notes are finally approved by XBRL International.

The promises of XBRL promoters that interactive data will revolutionize financial analysis and narrow the information asymmetry between individual investors and professionals are, at this time, still promises. Attention needs to be paid to the consumption of XBRL data and bringing the promises of XBRL to life. In developing the ITEM rubric, we first identified what individual investors needed in order to benefit from the revolution in financial analysis that XBRL proponents have promised. The point allocation worked well to draw attention to the important constructs while still taking into consideration the more mundane user interface issues.

We concluded that XBRL-enabled tools for investors are undoubtedly in their infancy. XBRL-enabled tools will become more sophisticated as software developers turn their resources away from the maturing area of report tagging and focus more upon how XBRL tagged information can be used. ITEM has the flexibility to evolve along with the changes in XBRL-enabled tools. We intend to refine this rubric and apply it to evaluate other XBRL –enabled tools.

In this paper we did not discuss the development of a tool for using the rubric. As demonstrated in the Appendices, we can use simple spreadsheets. However, once the rubric is perfected, it is worth developing an interactive tool for the application of the rubric.

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**Editor's Note:**

*This paper was selected for inclusion in the journal as the CONISAR 2010 Best Paper The acceptance rate is typically 2% for this category of paper based on blind reviews from six or more peers including three or more former best papers authors who did not submit a paper in 2010.*

## Appendix A

| | Available Points | SEC Viewer |
|---|---|---|
| **Interactivity** | **50** | **17** |
| **Searching** | **12** | **0** |
| Able to search on current statement | 1-3 | 0 |
| Able to search entire filing for specific item | 6-9 | 0 |
| **Exporting data** | **20** | **13** |
| Export or save each statement to .xls file format | 1-6 | 5 |
| Export or save entire SEC filing to .xls file in one step | 3-6 | 6 |
| Print statements | 1-2 | 2 |
| Export statements to PDF | 1-2 | 0 |
| Export statements to HTML file | 1-2 | 0 |
| Export statements to RTF | 1-2 | 0 |
| **Comparing data** | **14** | **0** |
| Compare different periods/filings of same company | 1-4 | 0 |
| Able to compare two or more companies | 1-5 | 0 |
| Able to compare current company to industry | 1-5 | 0 |
| Context | 2 | **2** |
| Can expand item to see context | 1-2 | 2 |
| **Taxonomy** | **2** | **2** |
| Can see taxonomy | 1-2 | 2 |
| **Analysis Functions** | **10** | **0** |
| Liquidity, profitability, and other common investment ratios | 5 | **0** |
| Common ratios calculated and displayed | 1-5 | 0 |
| **User defined calculations** | **3** | **0** |
| User is able to enter own calculations and see them displayed | 1-3 | 0 |
| **Charting** | **2** | **0** |
| Makes charts of data selected by user | 1 | 0 |
| Has pre-defined charts | 1 | 0 |
| **General Operation** | **24** | **20** |
| **Ease of Installation** | **3** | **3** |
| Web-based – no installation | 0-3 | 3 |
| Spreadsheet program add-in | 0-3 | |
| Download and installs per normal operation protocol | 0-3 | |
| **Terminology** | **4** | **4** |
| Extensive use of XBRL terminology | 0 | |
| Mixed use of XBRL terminology and "plain English" | 1-2 | |
| Use of traditional investment analysis terminology | 2-4 | 4 |
| **Design of the interface** | **7** | **4** |
| User can see all or most of individual statements without scrolling | 1-2 | 1 |
| Screen layout of statements is consistent | 1-2 | 2 |
| Use of color makes displays clear | 1 | 1 |
| Accessibility for users with disabilities | 1 | 0 |
| **Open company filing** | **10** | **9** |
| Viewer will locate and download the filing on EDGAR | 1-5 | 4 |
| User must locate and download the related files | 0 | 0 |
| Viewer automatically opens instance document | 1-5 | 5 |
| User has to initiate opening instance document | 0 | 0 |
| **Guidance** | **16** | **0** |
| **Help** | **6** | **0** |
| Searchable help function | 2-6 | 0 |
| **User manual or tutorials** | **10** | **0** |
| Available within the tool | 1-5 | 0 |
| Instruction document comes with the software | 1-3 | 0 |
| Available online from company website | 1-2 | 0 |
| **Total Points** | **100** | **37** |

**Appendix B**

| | SEC Viewer | Bowne Viewer | Dragon View | Xinba 2.o |
|---|---|---|---|---|
| **Interactivity** | | | | |
| **Searching** | | | | |
| Able to search on current statement | 0 | 0 | 3 | 0 |
| Able to search entire filing for specific item | 0 | 0 | 0 | 0 |
| **Exporting data** | | | | |
| Export or save each statement to .xls file format | 5 | 5 | 4 | 4 |
| Export or save entire SEC filing to .xls file in one step | 6 | 6 | 0 | 0 |
| Print statements | 2 | 2 | 2 | 2 |
| Export statements to PDF | 0 | 2 | 0 | 2 |
| Export statements to HTML file | 0 | 2 | 0 | 0 |
| Export statements to RTF | 0 | 0 | 0 | 0 |
| **Comparing data** | | | | |
| Compare different periods/filings of same company | 0 | 0 | 0 | 0 |
| Able to compare two or more companies | 0 | 0 | 0 | 0 |
| Able to compare current company to industry | 0 | 0 | 0 | 0 |
| **Context** | | | | |
| Can expand item to see context | 2 | 2 | 2 | 0 |
| **Taxonomy** | | | | |
| Can see taxonomy | 2 | 2 | 0 | 0 |
| **Analysis Functions** | | | | |
| **Liquidity, profitability, and other common investment ratios** | | | | |
| Common ratios calculated and displayed | 0 | 0 | 0 | 0 |
| **User defined calculations** | | | | |
| User is able to enter own calculations and see them displayed | 0 | 0 | 0 | 1 |
| **Charting** | | | | |
| Makes charts of data selected by user | 0 | 1 | 0 | 0 |
| Has pre-defined charts | 0 | 0 | 0 | 0 |
| **General Operation** | | | | |
| **Ease of Installation** | | | | |
| Web-based – no installation | 3 | 3 | | 3 |
| Spreadsheet program add-in | | | 2 | |
| Download and installs per normal operation protocol | | | | |
| **Terminology** | | | | |
| Extensive use of XBRL terminology | | | | |
| Mixed use of XBRL terminology and "plain English" | | | 2 | 2 |
| Use of traditional investment analysis terminology | 4 | 4 | | |
| **Design of the interface** | | | | |
| User can see all or most of individual statements without scrolling | 1 | 2 | 2 | 2 |
| Screen layout of statements is consistent | 2 | 2 | 2 | 2 |

| | | | | |
|---|---|---|---|---|
| Use of color makes displays clear | 1 | 1 | 1 | 1 |
| Accessibility for users with disabilities | 0 | 0 | 0 | 0 |
| **Open company filing** | | | | |
| Viewer will locate and download the filing on EDGAR | 4 | 5 | 0 | 0 |
| User must locate and download the related files | 5 | 5 | | |
| Viewer automatically opens instance document | | | 0 | 0 |
| User has to initiate opening instance document | | | | |
| **Guidance** | | | | |
| **Help** | | | | |
| Searchable help function | 0 | 0 | 0 | 0 |
| **User manual or tutorials** | | | | |
| Available within the tool | 0 | 0 | 0 | 0 |
| Instruction document comes with the software | 0 | 0 | 3 | 0 |
| Available online from company website | 0 | 2 | 0 | 0 |
| **TOTAL** | **37** | **46** | **23** | **19** |

# Factors Influencing People to Use Linux

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## Abstract

Linux is a free open source operating system that serves as a viable alternative to using Windows and other operating systems. Significant research has been conducted concerning Linux and why it is a reliable operating system. Yet, the question remains: Why aren't more people using Linux operating systems? To explore this question we researched two theories: the Theory of Planned Behavior and the Technology Acceptance Model, to better understand what factors influence a person's usage of Linux on a desktop or laptop computer. We used these theories to guide our research and limited the scope of our study to college students since they are readily available and will be entering the workforce within the next several years. To determine what factors influence people whether to use a Linux operating system, we conducted interviews (n=15) and a survey (n=168). We discovered that two constructs from the Theory of Planned Behavior (Attitude and Perceived Behavioral Control) and two constructs from the Technology Acceptance Model (Perceived Ease of Use and Perceived Usefulness) are significantly correlated with a person's intention to use a Linux operating system, while the Subjective Norm construct holds less importance.

**Keywords:** Linux, Windows, Theory of Planned Behavior, Technology Acceptance Model

## 1. INTRODUCTION

Operating Systems are essential for everyday computer usage. An operating system (OS) is defined as, "…the computer's master control program" (Operating Systems, 2009). People are beginning to realize that they have a choice in which operating system to use on their computers. Although Windows has the greatest amount of users, Linux has grown in popularity and is considered a successful Open Source Software Development project (Otte et. al, 2008).

Previous studies (Dedrick and West, 2004; West and Dedrick, 2001) have looked at the reasons why companies adopt open source software, but little research has specifically investigated why individuals use or do not use Linux. The purpose of this paper is to examine the factors that influence college students whether to use Linux on a desktop or laptop computer. Since these students will soon be entering the workforce, they will influence which operating systems to use in their homes and workplaces. This topic is important because both consumers and businesses look for ways to increase flexibility, stability, and performance, reduce the threat of viruses and spyware, and save money. Linux operating systems often offer these advantages.

The rest of our paper is arranged as follows: the Literature Review examines previous research regarding our topic, including several theories

that are applicable to this study. We state our hypotheses in the next section. The Methodology section explains how we used both interviews and surveys to collect data. In the Findings section, we provide the results from our analysis and test each hypothesis. We then discuss the implications of our findings in the Discussion section, which is followed by the Conclusion.

## 2. LITERATURE REVIEW

### Linux Usage

Linux is a free open source operating system originally developed by Linus Torvalds in 1991 (What is Linux, 2007). Linux operating systems can run on a myriad of devices such as desktops, laptops, PDAs, servers, and cell phones (Linux-Friendly Hardware, 2008). Versions of Linux have worked their way into every facet of society from education to government including the most common version of Linux (Fedora), Red Hat, and Ubuntu, one of the newest versions of Linux (What is Linux, 2007). Linux is a versatile and adaptable operating system. For the PC world as of December 2009, Windows holds approximately 92% of the total market share while Linux only holds 1.02% of the market share (Operating System Market Share, 2010). Even though Linux holds a small part of the market for operating systems, there are about 29 million Linux users in the world (The Linux Counter, 2010).

### Economic Value

Money drives decisions. Open source software, such as Linux operating systems, is free. The operating system for a computer is usually included in the overall package price. According to Microsoft.com (2010), the current price for Windows 7 Professional Upgrade is $199.99. Linux operating systems are usually free to download. For a computer purchase, removing the cost of the operating system saves money. Profit is a big focus for businesses, and consumers like to save money. Linux can run cost-effectively and reliably on larger computer systems (Varian et al., 2003). It is starting to play a bigger role in the business world (Powers, 2008).

### Awareness

One of the reasons Windows operating system use is more widespread than Linux is because many computer users are unaware of Linux. The majority of computer users are simply operating system choices exist. With the growth of the Internet, awareness of Linux operating systems has increased (West et al., 2001). Linux is gaining more users but does not come close to the number of Windows users because many computer users are unaware that it is an option.

### Flexibility and Quality

Linux operating systems are open source. This means users have access to the source code, which allows them to modify the operating system to fit their needs. Flexibility in an operating system is a preferred quality for some consumers. Users enjoy the ability to control Linux (Varian et al., 2003).

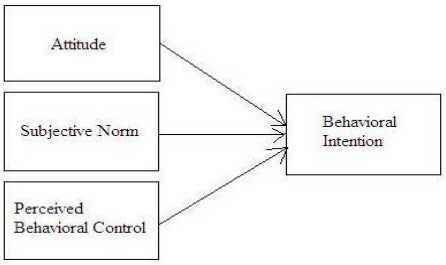
Quality is another important asset to operating systems. Some of the things that computer users look for in an operating system include a consistent interface, system updates, simple applications, and tech support (Powers, 2008). Linux provides these qualities as well as enterprise-grade software bundles with free anti-virus and anti-spyware tools (Powers, 2008).

### Theories

Two theories can be applied to explain what factors influence people whether to use a Linux operating system on a desktop or laptop computer. These theories are the Theory of Planned Behavior and the Technology Acceptance Model.

#### *Theory of Planned Behavior*

**Figure 1: Theory of Planned Behavior (after Ajzen, 1991)**



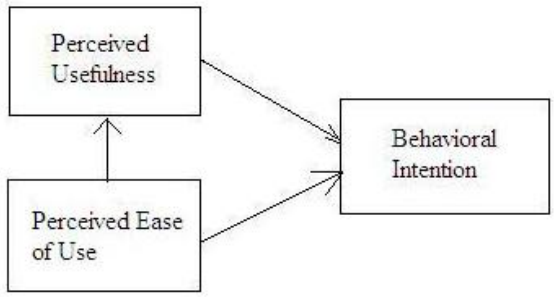

The Theory of Planned Behavior is centered around a person's intention to perform a certain behavior of interest (Ajzen, 1991). Behavioral intention is measured through three factors: Attitude, Subjective Norm, and Perceived Behavioral Control. The stronger the intention to

engage in a behavior, the more likely should be its performance (Ajzen, 1991). The Theory of Planned Behavior is illustrated in Figure 1.

***Technology Acceptance Model***

The Technology Acceptance Model examines an individual's willingness to accept and use available systems (Davis, 1989). The Technology Acceptance Model uses two factors to measure a person's intention of performing an action: Perceived Usefulness and Perceived Ease of Use (Lee et al., 2003). Perceived Usefulness is defined as, "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989). Perceived Ease of Use is defined as, "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989). The Technology Acceptance Model is helpful in measuring the factors that determine a person's acceptance of certain technology (Davis, 1989). Figure 2 illustrates the Technology Acceptance Model.

**Figure 2: Technology Acceptance Model (after Davis, 1989)**




## 3. HYPOTHESES

We derived five hypotheses to measure a person's intention to use a Linux operating system on a desktop or laptop computer. Hypotheses one through three are based upon the Theory of Planned Behavior:

**Hypothesis 1:** Attitude is positively correlated with Behavioral Intention to use a Linux operating system on a desktop or laptop computer.

**Hypothesis 2:** Subjective Norm is positively correlated with Behavioral Intention to use a Linux operating system on a desktop or laptop computer.

**Hypothesis 3:** Perceived Behavioral Control is positively correlated with Behavioral Intention to use a Linux operating system on a desktop or laptop computer.

Hypotheses four and five are based upon the Technology Acceptance Model:

**Hypothesis 4:** Perceived Usefulness is positively correlated with Behavioral Intention to use a Linux operating system on a desktop or laptop computer.

**Hypothesis 5:** Perceived Ease of Use is positively correlated with Behavioral Intention to use a Linux operating system on a desktop or laptop computer.

## 4. METHODOLOGY

To begin our study, we created an interview instrument based upon the Theory of Planned Behavior. After creating the interview instrument (see Appendix), we randomly selected and surveyed fifteen students in the College of Business at our university. Based upon the responses from the interviews, we created and emailed a survey to about 500 College of Business undergraduate students. We hosted the survey through the online site SurveyMonkey. One hundred sixty-eight (168) students started the survey and 158 of them completed it, making the response rate approximately 32%. We based our survey questions on constructs and statements from previous studies using the Theory of Planned Behavior (Ajzen, 1991) and the Technology Acceptance Model (Davis, 1989).

**Measures**

***Behavioral Intention***

We used two statements to measure Behavioral Intention: (BI1) I intend to Linux in the next three months, and (BI2) I plan to use Linux in the next three months. We computed Cronbach's alpha (.958) to test for reliability among the statements for Behavioral Intention.

***Attitude***

Three statements were used to measure Attitude: (ATT1) Using Linux is a good idea, (ATT2) Using Linux is a positive idea, and (ATT3) Using Linux is a helpful idea. Cronbach's alpha = .933 for these statements.

***Subjective Norm***

We used four statements to measure Subjective Norm: (SN1) My professors influence me in my decision whether to use the Linux operating system, (SN2) My friends influence me in my decision whether to use the Linux operating system, (SN3) My parents influence me in my decision whether to use the Linux operating system, and (SN4) Other people important to me influence me in my decision whether to use the Linux operating system. Cronbach's alpha =.780.

***Perceived Behavioral Control***

Four statements were used to measure Perceived Behavioral Control: (PBC1) I have the ability to use Linux, (PBC2) I possess enough knowledge to use Linux, (PBC3) I have the resources to use Linux, and (PBC4) I have the time to use Linux. Cronbach's alpha = .805.

***Perceived Ease of Use***

We used four statements to measure Perceived Ease of Use: (PEOU1) Learning to operate Linux would be easy for me, (PEOU2) I would find it easy to get Linux to do what I want it to do, (PEOU3) My interaction with Linux would be clear and understandable, and (PEOU4) I would find Linux easy to use. Cronbach's alpha =.942 for these statements.

***Perceived Usefulness***

Four statements were used to measure Perceived Usefulness: (PU1) Using Linux would enable me to accomplish computer tasks more quickly, (PU2) Using Linux would make it easier for me to use the computer, (PU3) Using Linux would be useful to me, and (PU4) Using Linux would increase my productivity. Cronbach's alpha =.920 for these statements.

**Demographics**

The gender breakdown for our survey is 53% male / 47% female. Students majoring in Accounting (15.5%), Computer Information Systems (8.9%), Economics (3.0%), Entrepreneurship (4.2%), Finance and Banking (6.5%), Healthcare Management (3.6%), Hospitality & Tourism Management (4.2%), International Business (7.1%), Management (20.2%), Marketing (13.1%), Risk Management and Insurance (0.6%), and other non-business majors (10.1%) responded to the survey, along with "undecided" majors (3.0%).

Table 1 shows the breakdown of class rank among the respondents.

**Table 1: Class Distribution**

| Year in College | Percent of Total |
|---|---|
| Freshman | 9.5% |
| Sophomore | 15.5% |
| Junior | 24.4% |
| Senior | 48.8% |
| Other | 1.8% |

## 5. FINDINGS

Table 2 summarizes the statements used to measure each construct. For all statements other than those for the Attitude construct, we used a seven-point Likert scale in which 1 = Strongly Agree and 7 = Strongly Disagree. The Attitude statements were also measured on a seven-point scale, in which positive responses received lower scores (i.e. 1 = "Very Good" and 7 = "Very Bad" for the first Attitude statement).

**Behavioral Intention**

As shown in Table 2, the average for the two Behavioral Intention questions = 5.01 for BI1 and 5.04 for BI2. This indicates that most students do not intend or plan to use Linux in the next three months. We also found through our interviews that a majority of students do not intend to use Linux. Several students said that would not consider using a different operating system. For example, one interviewee stated, "Mine works perfectly and I know how it works." Another person said, "I'm comfortable with what I have."

**Attitude**

The averages for the three Attitude questions (shown in Table 2) were 3.17 (ATT1), 3.09 (ATT2), and 3.27 (ATT3). These responses suggest that most students believe that using Linux would be a slightly good, positive, and helpful idea. Several of the interviewees who use a Windows operating system expressed frustration or dislike of their current operating system when asked, "How do you feel about your operating system and why?" One interviewee said, "I hate it because there are too many pop-ups and virus scans." This particular

interviewee uses Windows Vista. Another interviewee responded to the same question with, "Vista irritates me a lot because it's slow and has a lot of glitches." Another student summed up the stereotypes related to operating systems by stating, "Macs are for artsy people, Linux is for the computer folks, and Windows is for business and school types of stuff."

**Table 2: Summary of Statements Measuring each Construct**

| CONSTRUCT / STATEMENT | AVERAGE |
|---|---|
| **Behavioral Intention 1:** I intend to use Linux in the next three months. | 5.01 |
| **Behavioral Intention 2:** I plan to use Linux in the next three months. | 5.04 |
| **Attitude 1:** Using Linux is a _____ idea. (Very good - Very Bad) | 3.17 |
| **Attitude 2:** Using Linux is a _____ idea. (Very positive - Very Negative) | 3.09 |
| **Attitude 3:** Using Linux is a _____ idea. (Very helpful - Very unhelpful) | 3.27 |
| **Subjective Norm 1:** My professors influence me in my decision whether to use the Linux operating system. | 4.01 |
| **Subjective Norm 2:** My friends influence me in my decision whether to use the Linux operating system. | 3.88 |
| **Subjective Norm 3:** My parents influence me in my decision whether to use the Linux operating system. | 4.61 |
| **Subjective Norm 4:** Other people important to me influence me in my decision whether to use Linux. | 3.99 |
| **CONSTRUCT / STATEMENT** | **AVERAGE** |
| **Perceived Behavioral Control 1:** I have the ability to use Linux. | 2.49 |
| **Perceived Behavioral Control 2:** I possess enough knowledge to use Linux. | 3.86 |
| **Perceived Behavioral Control 3:** I have the resources to use Linux. | 3.42 |
| **Perceived Behavioral Control 4:** I have the time to use Linux. | 3.67 |
| **Perceived Ease of Use 1:** Learning to operate Linux would be easy for me. | 2.94 |
| **Perceived Ease of Use 2:** I would find it easy to get Linux to do what I want it to do. | 3.37 |
| **Perceived Ease of Use 3:** My interaction with Linux would be clear and understandable. | 3.41 |
| **Perceived Ease of Use 4:** I would find Linux easy to use. | 3.44 |
| **Perceived Usefulness 1:** Using Linux would enable me to accomplish computer tasks more quickly. | 3.73 |
| **Perceived Usefulness 2:** Using Linux would make it easier for me to use the computer. | 3.82 |
| **Perceived Usefulness 3:** Using Linux would be useful to me. | 3.51 |
| **Perceived Usefulness 4:** Using Linux would increase my productivity. | 3.92 |

**Subjective Norm**

Depending upon the student, one or more referent groups influenced their operating system choice. The most common responses

from the interviews include professors, friends, and parents. In response to a question concerning whether others influenced their choice of their current operating system, one female interviewee indicated, "My parents I guess because they are the ones that bought my computer for me." The averages from the four survey questions (from Table 2) suggest that none of these groups are very influential in a student's decision whether to use Linux.

**Perceived Behavioral Control**

Perceived behavioral control deals with those things that may be outside a person's volitional control. The survey results indicate that most students believe they possess the ability to use Linux (PBC1 = 2.49). The statements about possessing enough knowledge (PBC2 = 3.86), resources (PBC3 = 3.42), and time (PBC4 = 3.67) received lower averages than PBC1. Many of the interviewees were unaware of Linux. The interviewees were aware of Windows operating systems and Mac operating systems. Many of the interviewees had never used a Linux operating system before and were only familiar with Windows operating systems or Macs. In a response to factors that would influence a student to use Linux, one person said, "It simply costs money I don't have." Some respondents are obviously unaware that Linux is a free operating system.

**Perceived Ease of Use**

As shown in Table 2, the survey responses for the Perceived Ease of Use construct were slightly positive (PEU1 = 2.94; PEU2 = 3.37; PEU3 = 3.41; PEU4 = 3.44). Many of the interviewees said they would be willing to try Linux if it would be easier to use than their current operating system. When asked if they would consider using a different operating system, one interviewee stated, "Yes, if it was more efficient and easier to use." Several Mac users indicated that they would probably *not* switch operating systems because their current system is easy to use. Most interviewees agreed that ease of use is a quality they look for in an operating system.

**Perceived Usefulness**

The survey responses for Perceived Usefulness were also slightly positive (see Table 2 – PU1 = 3.73; PU2 = 3.82; PU3 = 3.51; PU4 = 3.92). Overall, students agreed that Linux would help them accomplish tasks more quickly and increase their productivity. One student stated that they prefer Linux over Windows because, "It doesn't freeze up as much and my computer hasn't crashed yet." Another interviewee said that would consider using another operating system, "…if there were a better option that could do more and had better functions."

**Correlation Analysis**

**Table 3: Correlation Matrix**

| | ATT | SN | PBC | PU | PEU |
|---|---|---|---|---|---|
| BI | .590** | .086 | .378** | .446** | .480** |
| PEU | .514** | .118 | .475** | .368** | |
| PU | .600** | .311** | .246** | | |
| PBC | .448** | .166* | | | |
| SN | .306* | | | | |

*p < .05, and **p < .01

We used SPSS 15.0 to compute the correlations among the constructs. As shown in Table 3, ATT = Attitude, SN = Subjective Norm, PBC = Perceived Behavioral Control, PU = Perceived Usefulness, PEU = Perceived Ease of Use, and BI = Behavioral Intention. We tested our hypotheses based upon the correlations in Table 3.

**Hypothesis 1**, Attitude is positively correlated with Behavioral Intention to use Linux operating systems on a desktop or laptop computer, is supported (r = .590; p < .01).

**Hypothesis 2**, Subjective Norm is positively correlated with Behavioral Intention to use Linux operating systems on a desktop or laptop computer, is not supported (r = .086, p > .05).

**Hypothesis 3**, Perceived Behavioral Control is positively correlated with Behavioral Intention to use Linux operating systems on a desktop or laptop computer, is supported (r = .378, p < .01).

**Hypothesis 4**, Perceived Usefulness is positively correlated with Behavioral Intention to use Linux operating systems on a desktop or laptop computer, is supported (r = .446, p < .01).

**Hypothesis 5**, Perceived Ease of Use is positively correlated with Behavioral Intention to use Linux operating systems on a desktop or

laptop computer, is supported (r= .480, p < .01).

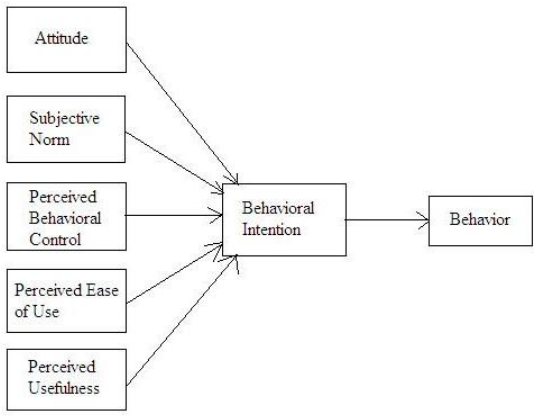
## 6. DISCUSSION

Our interview and survey results indicate that many people do not know much about Linux operating systems. We need to better inform people, especially students, about Linux and the advantages and disadvantages of using it. Several misconceptions and stereotypes about Linux should be clarified, such as Linux's cost and the idea that it is only for "computer people."

Businesses should also be better informed of Linux as an alternative to using Windows operating systems, as Linux offers several advantages over Windows. In today's economy, businesses looking to upgrade computer systems can choose Linux to cut costs.

Our findings show that constructs from both the Theory of Planned Behavior (*Attitude* and *Perceived Behavioral Control*) and the Technology Acceptance Model (*Perceived Ease of Use* and *Perceived Usefulness*) are significantly correlated with Behavioral Intention. We have combined the main constructs from these two theories in Figure 3.

**Figure 3: Combination of Theory of Planned Behavior/Technology Acceptance Model**




We were surprised that a significant positive correlation does not exist between Subjective Norm and Behavioral Intention, as much previous research using the Theory of Planned Behavior (Ajzen, 1991) has discovered significant relationships between these constructs. For future work, we plan to collect more data so that we can further analyze the relationships among the constructs from these two theories. With additional data, the Subjective Norm construct may show more importance. We also plan to gather and analyze data from professionals instead of students to find out which constructs are most important.

## 7. CONCLUSION

Our research reveals the factors which significantly influence people's intentions to use Linux on a desktop or laptop computer: Attitude, Perceived Behavioral Control, Perceived Ease of Use, and Perceived Usefulness. We believe that Linux operating systems will continue to become more popular as computer users are educated that Windows operating systems are not the only option. Conducting additional research in this area will provide more insight on the factors influencing people to choose to adopt Linux.

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**Editor's Note:**

*This paper was selected for inclusion in the journal as a CONISAR 2010 Meritorious Paper. The acceptance rate is typically 15% for this category of paper based on blind reviews from six or more peers including three or more former best papers authors who did not submit a paper in 2010.*

## Appendix – Interview Questions

1. Do you use multiple operating systems? If so, which do you prefer and why?
2. Which operating systems are you familiar with? Are you aware of Linux operating systems?
3. Would you consider using a different operating system? Why? Follow up questions about what factors would encourage or discourage them from using another OS.
4. What influences you when choosing an operating system? Do you think about using a different operating system when choosing?
5. What do you know about computer operating system types?
6. What are your thoughts about operating systems?
7. How do you feel about your operating system? Why? (Love it, hate it, irritating, happy with it, etc.)
8. What are some of the things that might make you consider changing operating systems?
9. How did you decide on your current operating system?
10. Did anyone (parent, teacher, friend, co-worker, etc.) influence you on your decision to use your current operating system?

# How Mobile Technology is Changing Our Culture

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## Abstract

Cell phones have become ubiquitous within our society, and many would now consider them a necessity rather than a convenience. This widespread use of cell phones and other mobile communication devices has brought with it an increasing acceptance of their use in virtually all social situations. It is no longer taboo to be caught with a ringing cell phone at a dinner with family and friends, at a sporting event, or even during a church service. Incoming calls are no longer seen as interruptions of the primary activity taking place, but are instead treated as equally important communications. Proximity is becoming inconsequential in terms of social interaction. This study seeks to determine how mobile technology has changed our culture and identifies the ways in which we now perceive socially acceptable communication.

**Keywords:** mobile technology, cell phones, culture, communication

### 1. INTRODUCTION

It is becoming increasingly acceptable to have and use cell phones and other mobile devices in social situations as more people are choosing to use cell phones than landline phones. The way we view communication and the appropriateness of certain types of communication behaviors is fundamentally changing. We have moved into an era where phone numbers refer to people instead of places. A cell phone is a constant companion that accompanies a person throughout their daily life and allows them the convenience of easy communication and access to information.

This cultural shift to an "always-on" world brings challenges along with the conveniences. Now, when a call is placed to someone on their cell phone, it is fully expected that the call will be answered because most people assume that a cell phone accompanies a person everywhere, regardless of their location. Even if someone is out of town or on vacation, the expectation remains the same because the cell phone is attached to the person rather than a specific place like a home or office.

There is no longer any assumption of private time – people are increasingly expected to be accessible at all times, and physical location is no longer of any importance or concern. Problems can arise as the boundaries between personal time and times when people are expected to be available continues to blur. We need to clearly understand the cultural shift that

mobile devices are creating within our society, and work to lessen some of the problems and challenges that it has caused.

This study seeks to determine how mobile technology has changed our culture and identify the ways in which we now perceive socially acceptable styles of communication. To this end, we explore the following research questions:

RQ1: Has it become socially acceptable to have and use mobile devices in all social situations?

RQ2: Has it become socially acceptable to be continually available via mobile devices?

The remaining sections of this paper will present the background and findings of the current study.

## 2. LITERATURE REVIEW

Mobile technologies have become a normal part of everyday life. More people now have cell phones than landline phones, both within the United States and internationally (Rosen, 2004). In fact, so many people have terminated their landline services in favor of having only cell phones that a term has emerged to describe this action – it's called "cutting the cord" (Townsend, 2000). The cell phone phenomenon is not limited to adults; in fact, it is not uncommon to see high school and middle school students with their own cell phones. When walking through a department store, or strolling down a crowded city street, or taking a ride on public transportation, it is completely common to hear others having cell phone conversations (Rosen, 2004).

A 2009 study conducted by Kakabadse, Kakabadse, Bailey & Myers (2009) surveyed 1, 277 students, ages 11-18, in regard to mobile phone calls and text messaging. A total of 267 surveys were returned. Ninety-five percent of students reported having access to a computer/laptop, mobile phone and /or the Internet. Approximately 17 percent of students identified that they spent at least three hours per day on a mobile phone. The majority of students indicated that they sent and/or received 20 text messages per day. Only five percent of students sent or received over 60 texts per day. Of the students that sent and received text messages 29 percent used text short cuts when completing school work. Students were asked a series of questions in regard to phone usage in the classroom. Over 50 percent reported that having a mobile phone in the classroom or a ringing cell phone in class did not distract them from their studies. Over 73 percent of students made no excuse to leave the classroom to answer their phone, while 22 percent apologized for causing inconvenience in the classroom. One-third of students indicated they would make a call from their mobile phone during class (Kakabadse et al., 2009).

In 2010, cell phones and other mobile devices are not simply used for telephone communications or even text messaging. Many mobile devices today can also access the Internet and run a variety of applications, making them the equivalent of a pocket-sized computer with wireless Internet access. People can now conduct banking, check sports scores and stocks, read news, watch YouTube videos, play games, find directions and maps, book travel plans, and lookup information at the touch of a button – from anywhere. The boundaries of activities and locations are becoming blurred. (Agre, 2001).

While cell phones can provide many conveniences, they have also begun to shift how people interact in public situations. People carry on entire conversations in public on their cell phones. Although it is up for debate as to why public cell phone conversations may seem more bothersome than normal conversations, it may be because the conversations of people standing nearby are two-sided conversations. When listeners can hear both sides of the discussion, the conversation is quantitatively greater (Rosen, 2004). When listeners hear only half of a cell phone conversation, it becomes more like "noise" and can be seen as a socially undesirable behavior. The cell phone user is sending a very clear message to others nearby that they are powerless to stop the "noise" – a very passive aggressive tactic (Rosen, 2004). Nevertheless, more and more people talk on their cell phones in public spaces.

Only five to ten years ago it would have been considered taboo to take phone calls during a lunch or dinner with friends. Now, if a cell phone rings, it is fully expected that the call or text will be answered. Sociologist Erving Goffman (1963) studied and mapped the many and varied types of human and social interaction in a time before cell phones. Now, his observations can be seen in a new light as they take on relevance in a world of mobile technology. Rosen (2004) states, "Although Goffman wrote in the era before cell phones, he might have judged their use as a 'subordinate activity,' a way to pass the

time such as reading or doodling that could and should be set aside when the dominant activity resumes" (Rosen, 2004, p. 38).

In various ways, the blurring of boundaries between activities and locations has resulted in a higher level of convenience for most people. But it has also presented a series of challenges that are just now beginning to surface. If a person always carries a mobile device, employers have instant access to them. The whole concept of a vacation is breaking down as employers know that an employee can be reached at the touch of a button for that one small question that is such high priority that it can't wait until they return to work (Agre, 2001). People can also now access email from their mobile devices, so urgent work emails can be dealt with during time off with no need to wait for a return to the office on Monday morning.

While work life may begin to intrude upon personal life, challenges also exist in the opposite direction. Employees who use social networking sites such as Twitter and Facebook to keep in touch with friends can find that these activities often extend themselves into the workday. Even if employers block these sites from use on company-owned computers, many employees can still access the sites via their cell phones. When a person's social network includes co-workers as well as friends and family, it can also become increasingly difficult to keep personal life separate from work life. There have been several reported cases where employees were fired because they either fraudulently "called off" work due to illness, yet posted their activities (clearly showing they were not ill but "playing hooky") or were fired for posting other employer-related comments (Matyszczyk, 2009; Sondergaard, 2009).

Other dangers related to cell phone use can affect those who talk or text on their cell phones while driving. A 2010 Driving While Distracted (DWD) survey conducted by Nationwide Insurance revealed that 38 percent of Americans say they have been hit or almost hit by a driver distracted by their cell phone. The study also showed that 1 in 4 Americans use downloaded applications such as GPS, sending and receiving email, searching the Internet and reading and posting messages to Facebook and Twitter (Carnegie Mellon University, 2009). A 2009 study conducted by Carnegie Mellon University revealed that 25 percent of police-reported crashes showed that DWD was a factor. Additionally, driving while using a cell phone reduces the amount of brain activity associated with driving by 37 percent (Nationwide Insurance, 2010). The findings of these studies indicate a person's need to stay connected even at the risk of hurting themselves or someone else.

Another danger is addiction to technology. There are many people who compulsively read their messages at all times of the day. The use of the BlackBerry brand of smart phones is commonly cited for its addictive nature (Locher, 2007; Zeman, 2007). BlackBerry phones have also been described as "electronic pets" because business people are often seen stroking the scroll wheel and giving the device constant attention as if it were a pet. Phones are decorated with various styles of carrying cases, covers, and holstering devices, further pushing the metaphor of a pet that is "dressed up" (Rosen, 2004). Individuals tend to develop very personal relationships with mobile phones, customizing them by entering commonly called numbers, music, and applications that they enjoy. Phones have become so addictive that they are being perceived more and more as an extension of the body, in a virtual sense rather than a physical one (Townsend, 2000). In fact, many people who normally carry cell phones at all times report that they feel "lost" or "naked" if they accidentally leave their cell phone behind (Alexander, Ward & Braun, 2007). Many of these people would make a separate trip to retrieve a phone just so that they can continue to feel safe and connected. A 2010 survey conducted by Bradley (2010) found that 8 of 10 business professionals would rather give up coffee than surrender their smart phone.

## 3. METHODOLOGY

This study examined the dependence on mobile technologies of undergraduate and graduate students ages 18 or older at a mid-Atlantic university. The researchers selected a quantitative methodology and designed a survey based on previous literature on technology dependency.

The survey questions focused on obtaining information from students on technology dependency. The survey questionnaire was a five-page, 39 question document which was comprised of four sections. The first section focused on participant demographics to include gender, age, and education. The second section addressed the students Internet and cell phone usage, including the use of text messaging and social networking sites. The third section focused

on the student's level of need for technology to complete their daily activities. Lastly, the fourth section sought information regarding the student's reliance on technology.

The study was a convenience sample surveying 88 undergraduate and graduate students. A 5% margin of error with a 95% confidence level was used. The researchers administered the survey to students from the School of Communications and Information Systems during scheduled class times in January 2010. Students were informed that taking the survey was strictly voluntary and would not impact their current or future relations with the university.

## 4. RESULTS

The objective of this study was to examine the cultural effects of mobile technology usage on university students and identify situations in which they perceive the use of mobile devices to be socially acceptable. Male and female genders were not represented in proportion in the participant sample. More than half of the research participants were male, 68% (58), while 34% (30) were female. Of the 88 students, 40 students were between the ages of 20-29, 29 were ages 30-39, 13 were ages 40-49 and 6 were ages 50 and over. The age breakdown is illustrated in Table 1.

Table 1

*Age Groups of Sample*

| Age Group | # of Participants |
|---|---|
| 20-29 | 40 |
| 30-39 | 29 |
| 40-49 | 13 |
| 50+ | 6 |

Research Question 1 sought to determine if it has become socially acceptable to have and use mobile devices in all social situations. Seventy-three percent (64) of survey participants said that they talk on their cell phone regularly in public places, while 27% (24) do not. In order to determine how socially acceptable students found the use of cell phones in varied social settings, the survey asked if they have ever answered their cell phone in a store, at a sporting event, while at lunch or dinner with friends, in class, in a meeting, in a movie theatre, in church, or at a funeral. The majority of students reported that they have answered their cell phones while in a store (99%), at a sporting event (86%), and while at lunch or dinner with friends (91%). Fewer students reported answering their cell phones in class (33%). These responses are summarized in Figure 1.

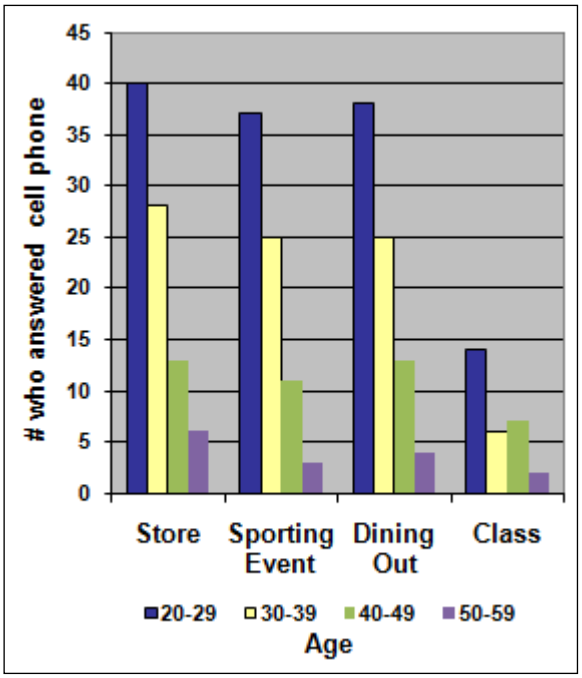


*Figure 1 – Number of students who answered their cell phone in the first four social settings by age group*.

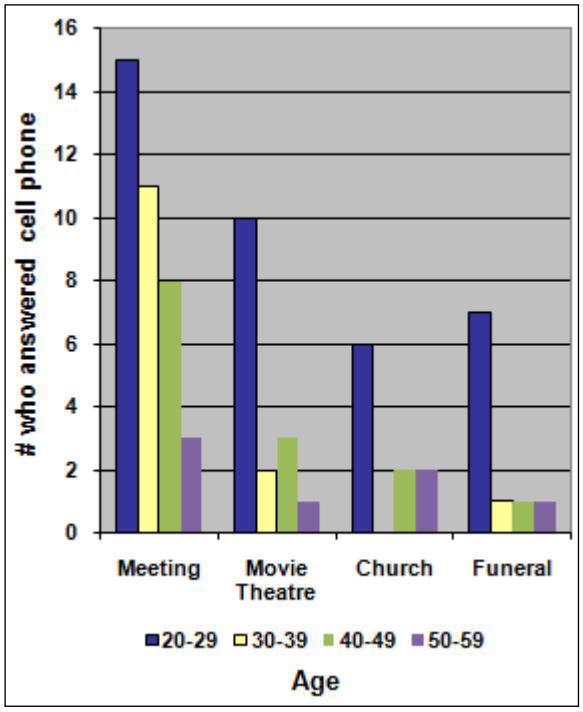


*Figure 2 – Number of students who answered*

*their cell phone in the second four social settings by age group*.

A number of students reported answering their cell phones in a meeting (42%). The least number of students reported answering their cell phones in a movie theatre (18%), in church (11%), and at a funeral (11%). While the numbers in this last grouping are significantly lower, it is still important to point out that culture regarding mobile devices and interruptions has shifted to such an extent that 10-20% of students feel that it is alright to answer their cell phone in a movie theatre, church, or during a funeral. Figure 2 illustrates the number of students who answered their cell phone in each of these social settings.

The survey also addressed how socially acceptable it has become to use a cell phone while driving. Of the participants surveyed, 91% (80) said that they talk on their cell phone while driving, while 9% (8) did not. When asked if they texted while driving, there was an even split with 50% (44) saying that they did text while driving and 50% saying that they did not.

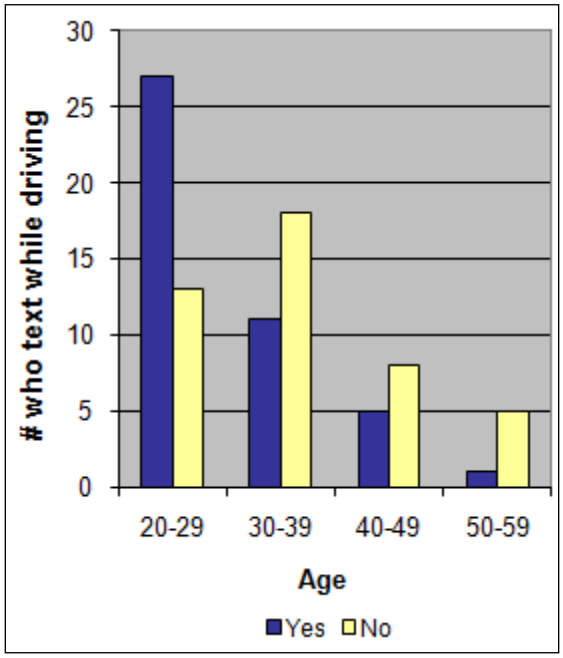


*Figure 3 – Number of students who text while driving, by age.*

Several articles and studies (Leighton, 2010; Madden & Lenhart, 2009; Nugent, 2008; Texting while driving, 2008; Thompson, 2006) have recently indicated that driving while text messaging may be more dangerous than driving while under the influence of alcohol. A recent study by the Pew Internet & American Life project (Madden & Lenhart, 2009) found that one in four (27%) American adults say they have texted while driving. The same study found that an almost identical proportion (26%) of driving age teens said that they have texted while driving, indicating that adults are just as bad as teenagers when it comes to this potentially dangerous activity (Madden & Lenhart, 2009; Muaddi, 2010). In our sample, no teenagers were included (the youngest age group was 20-29), but we did find that there is a statistically significant relationship between age and whether or not the student texts while driving (chi-square = 9.949, *df* = 3, p= .019). The younger students in our sample, ages 20-29, say that they text while driving much more than their older classmates. As age increased, the students were less likely to text while driving, as shown in Figure 3.

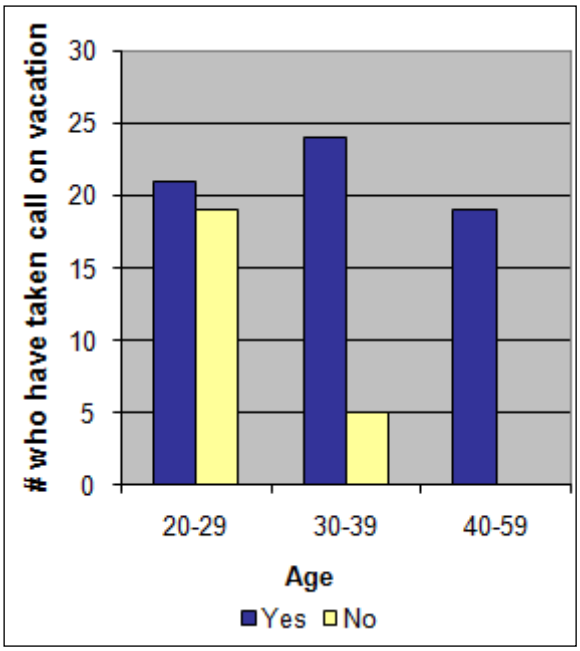


*Figure 4 – Students who have taken work related calls on vacation by age.*

Research Question 2 sought to determine if it has become socially acceptable to be continually available via mobile devices. In order to determine the extent to which they needed to stay connected in an "always-on" world, students were asked if they ever took a work related phone call while they were on vacation. A majority of 64 students, 73%, answered yes and 24 students, 27%, answered no. There is a statistically significant relationship between age and taking a work related phone call while on

vacation (chi-square = 16.847, *df* = 2, p = .001). As a student's age increases, the likelihood of them taking a work related phone call while on vacation increases. Approximately 82% of students between the ages of 30 and 39 have taken work related calls while on vacation. Additionally, 100% of students over the age of 40 have taken work calls on vacation. Only 52% of younger students, between the ages of 20 and 29, have taken work related calls on vacation. Figure 4 shows students who have taken work related calls while on vacation, broken down by age.

In order to determine the extent to which students found it socially acceptable to answer a cell phone call during a face to face meeting, the survey asked students if they think it's rude if someone takes a phone call while meeting or speaking with them. Sixty-three percent (55) of students said that they felt it was rude, while 37% (33) said that they did not feel it was rude.

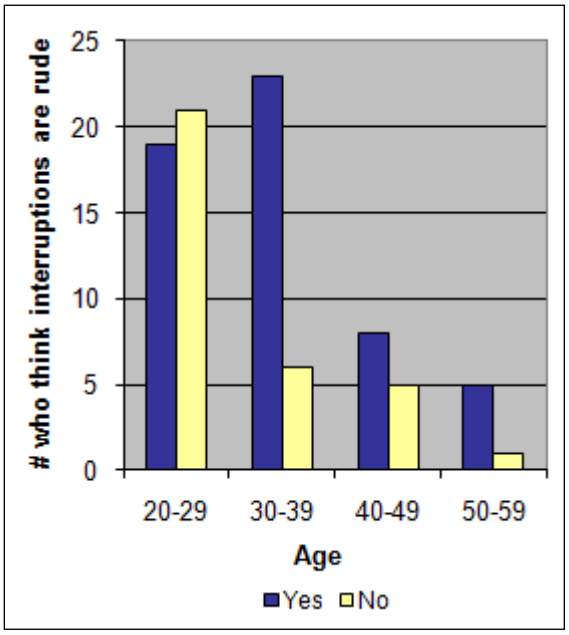


*Figure 5 – Students who think taking cell phone calls during a face-to-face meeting is rude, by age.*

The researchers found a statistically significant relationship between age and whether or not a student felt that it was rude to be interrupted by a phone call (chi square = 8.453, *df* = 3, p = .038). As a student's age increases, the likelihood that they felt being interrupted by a phone call was rude also increases. Approximately 47% of students between the ages of 20 and 29 felt it was rude, while 79% of students ages 30-39, 62% of students ages 40-49, and 83% of students ages 50-59 felt it was rude. Figure 5 shows the number of students who think interrupting cell phone calls are rude.

The extent to which students use mobile technologies on a daily basis is also an indicator of how socially acceptable they feel it is to have and use the devices. Survey questions addressed how the students receive the majority of their phone calls. Approximately 75% (66) of participants receive the majority of their phone calls by cell phone, contrasted with only 9% (8) who receive the majority of their calls via landline. Sixteen percent (14) of the participants stated that they receive the majority of their phone calls via text message.

The majority of students, 93% (82), indicated that they do use text messaging in general as a form of communication. Of the students who text, 53% (47) said that they prefer texting to making a phone call, while 47% (41) students said that they did not. Upon examining the age of the students along with their preference, we found that there is a strong, statistically significant relationship between age and texting preference (chi square = 23.409, *df* = 3, p = .000). In a recent study on the impact of text messaging on communication, Hemmer (2009) found that participants believed that text messaging is used to avoid face-to-face communication. In our sample, younger students clearly preferred texting to making a phone call, while older students preferred making a phone call and speaking to the other person rather than texting.

The survey asked participants how many text messages they send on average per day. On average, the 88 students surveyed send 22 text messages per day. There is a statistically significant relationship between age and number of texts sent (chi-square = 30.298, *df* = 18, p = .035). As a student's age progresses, the number of texts sent becomes fewer and fewer.

## 5. DISCUSSION

This study sought to determine whether it has become socially acceptable to have and use mobile devices in all social situations. After asking students whether they have taken a phone call in a variety of social settings, it's clear that standards for socially acceptable communication behaviors are changing. A majority of students reported that they had answered calls while in public places including stores, sporting events, and restaurants. This

indicates that there is no longer any social expectation that these types of public or semi-public areas are off-limits for personal calls. A person's primary experience is no longer considered to be more important than their secondary experiences while connecting digitally to others at the same time.

While it may have been taboo to take a phone call at our grandparents' dinner tables, it seems clear that this is no longer the case in today's society. People are now expected to respect each individual's right to withdraw from the social group at any time through their cell phones or other mobile devices. Rosen (2004) postulates that sociologist Erving Goffman would have considered cell phone use a "subordinate activity" that should not be allowed to impose upon the social group as a whole or to overtake the primary activity – meaning that face-to-face communication should be respected and other calls should wait until later. We would argue that most people use their mobile devices to communicate in some way with other friends, family members, or colleagues who may not be sitting at the table. The action of communication itself, whether speaking on the phone, text messaging, commenting on Facebook, or updating your geo-location, is actually still a dominant activity. It is in fact, the same activity that is going on with the people sitting at the table. The difference lies in the fact that we now seem to perceive that proximity does not necessarily dictate our undivided attention. We now see our entire social network of people as equals, regardless of whether we are sitting face-to-face with them or miles away.

Respect for certain traditional social behaviors is also clearly in jeopardy. Eleven percent of students indicated that they had answered a cell phone call while at a funeral. While this is admittedly a small percentage, it's still large enough to have surprised us when we reviewed the results of the survey. It seems that while the majority of students did respect the tradition of a funeral enough to abstain from cell phone use, the fact that some students did not is indicative of the fact that mobile technology is continuing to push the boundaries of our acceptable social customs and behaviors.

This study also sought to determine whether it has become socially acceptable to be continually available via mobile devices at all times. Based on the statistics of cell phone usage versus landlines, it is apparent that we are shifting toward a mobile "always-on" world where everyone is digitally connected to their social group at all times.

It seems quite clear from our sample that younger students are more likely to prefer texting to phone calls or face to face communication, while older students are less likely to prefer texting and send fewer text messages on average per day than their younger classmates. However, older students may feel more obligation to the always-connected world, at least in terms of work, since more students over the age of 30 have taken at least one work-related call while they were on vacation. Only 52% of younger students, between the ages of 20 and 29, have taken work related calls on vacation. This lower percentage for younger students could be due to the fact that younger students have not yet entered the workforce or have not yet had the opportunity to be called upon to work during vacation in their early careers. This trend in general provides evidence that the boundaries between private life and work life are already blurring, and will likely continue to blur further in the future.

## 6. LIMITATIONS

The research reported in this study was limited to the School of Communications and Information Systems. The demographic characteristics revealed that male participants outnumbered female participants. This could have been attributed to conducting the survey using students from a school in which the majority of the students are male.

Additionally, the demographic characteristics revealed that the ages of participants included in the study were not equally distributed. There were a larger number of younger participants included, due to the nature of the sample. Conclusions cannot be generalized for the over 50 age group, which was represented by only 6 participants out of 88.

## 7. CONCLUSION

We are now living in a world where disruptive communication is acceptable. Interruptions are no longer frowned upon; they are simply expected as part of the normal social activity. Even places where cell phone interruptions have long been considered taboo, such as a movie theatre, church, or funeral, are starting to see more and more people challenging tradition and answering their cell phones.

Based on the findings of this study, we do think that a significant culture shift is occurring amidst our society. Our sample shows that younger individuals were both more likely to engage in cell phone usage in a variety of social settings and also were less likely to find this type of communication to be rude or disruptive.

While everyone can and should decide for themselves where their limitations and boundaries exist in relation to cell phone usage in public, it remains a serious concern as to how social conventions will continue to change in the workplace. Clear limitations and boundaries need to be set for workplace communication protocol, so that both employers and workers understand the expectations of one another regarding availability.

The idea that phone numbers now refer to people instead of places is an interesting one. It means that not only is physical location irrelevant, but it also provides us with some continuity of identity. If a person leaves one employer and moves to another, their cell phone number stays with them and their identity is not necessarily tied to that employer, office location, or industry. Instead of working in a network full of places and businesses, we are moving toward working in a network of connected people. In this regard, the cultural shift could provide many interesting changes and opportunities in the future.

Future studies should focus on a deeper understanding of the cultural shifts that are happening in relation to mobile technologies, and a broader range of survey participants across multiple disciplines and age groups should be utilized.

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# Appendix

## 1. EXAMPLE SURVEY QUESTIONS

Do you prefer texting to making a phone call? (Yes/No)

Have you ever taken a work related call while you were on vacation? (Yes/No)

Have you ever answered your cell phone for each of the following? (Yes/No)

- In a store
- In class
- In a meeting
- At a funeral
- At a sporting event
- While at lunch or dinner with friends
- In church
- In a movie theatre

Do you think it's rude if someone takes a phone call while they are meeting or speaking with you? (Yes/No)

# Creating a Framework for Research on Virtual Organizations

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## Abstract

In recent years the concept of the virtual organization (VO) has received a great deal of attention in both the business press and academia. While a fair amount of research has focused on the virtual organization, very little agreement exists on how to define it, or even approach it as a concept or an organizational form. This makes it difficult to build a coherent research stream in virtual organizations, as there is no good way to link the research that has been done. In fact, it is impossible to relate or compare the research that has been done under various definitions of the VO without a common framework to relate them to one another. The purpose of this paper is not to develop another definition of the virtual organization, but rather to provide a definitional framework for the virtual organization which can assist researchers in relating the work done on VO's using various definitions.

**Keywords**: Virtual Organizations, frameworks, virtuality, outsourcing

### 1. INTRODUCTION

With the adoption of the Internet and other associated computer and telecommunications technologies by organizations worldwide, a great deal of attention has been paid to the new forms of organizing these technologies have enabled (Drucker 1998; Hughes, O'Brien et al. 2001). The distributed and pervasive nature of the Internet, and the ease with which companies can now communicate across great distances, have made new forms of organizing possible for companies. These various forms of organizing have attractive benefits for firms, including cost savings and increased flexibility (Drucker 1998). As companies have taken advantage of these new technologies to distribute their work and workers, they have moved towards being "virtual organizations".

But what is a virtual organization? Despite the widespread use of the term in the press since it's conception in the early 1980's (Mowshowitz 1994), there seems to be little agreement in the academic literature on what, exactly, this is. Some of the definitions are exclusive, trying to define the exact qualities of a VO (Walter 2000; Rahman and Bhattachryya 2002). For example, "a temporary network of independent linking by Integrated Technology to share skills, costs, and access to one another's markets" is one definition (Rahman and Bhattachryya 2002). This definition certainly conjures the image of an organization that is the opposite of every "traditional" brick and mortar organization.

Other definitions tend to be more inclusive, viewing the VO as a trend or framework rather than a specific type of organization (Venkatraman and Henderson 1998;

Mowshowitz 2002; Shekhar and Ganesh 2007). For instance, Venkatraman and Henderson (1998) state "…we treat virtualness as a strategic characteristic applicable to every organization". An example of an inclusive definition is "A virtual organization is any organization with non-co-located organization entities and resources, necessitating the use of virtual space of interaction between the people in these entities to achieve organization objectives" (Shekhar and Ganesh 2007).

Regardless of which definitions are used, the organizations in question are referred to as "virtual", both in the business and academic literature. This can present some problems, as the first definition presented could POTENTIALLY be applied to the open source software movement, while the last definition could be used to refer to any modern multinational company. The use of multiple, conflicting, definitions in various articles leads to problems for the researcher. Which research findings, using which definitions, can be applied to any given piece of research? How can we, as researchers, determine which articles contain theory that could be used for a given research setting? This has lead to some confusion within the field and serves as a barrier for developing and applying theories to this phenomenon.

This situation is further complicated by the fact that outsourcing is, conceptually, closely related to the virtual organization. By outsourcing certain activities, an organization is becoming more virtual (Shekhar and Ganesh 2007). The many concerns and challenges associated with outsourcing various business functions are generating a great deal of interest within the literature, again both popular and academic, because of the possible benefits and pitfalls of following this strategy. This important area of study falls under the enormously broad umbrella of virtual organizations. Finding a way to align the concept of the virtual organization and outsourcing would be very valuable for research, as it would provide the field with a common point of reference. The framework presented in this paper could be used to help determine the common ground between the research on virtual organizations, and that of outsourcing.

A common framework for definitions of the virtual organization would allow the academic community to have a common frame of reference, and would also allow us to more easily establish boundary conditions for the theories that are used to study these organizations. This is required for progress to be made in this area, as it does not seem reasonable to assume that a theory that works in a purely traditional organization would work in a purely virtual one or vice versa. And, again, the broad varieties of the definition of virtual cause problems here. If a study finds a certain factor contributes to success for one definition of the virtual organization, would it contribute to all of them? Rather than saying the research is examining a virtual organization, it would be able to specify the *type* of virtual organization within that common framework. The purpose of this paper is to examine the existing literature on virtual organizations and then suggest a common framework for that research.

This is done by first presenting a review of the literature in section 2. In section 3, the proposed definitional framework is presented and defined. In section 4 future work in this area is discussed, and section 5 presents the conclusion.

## 2. LITERATURE REVIEW

The term virtual organization was first introduced to the language in the early 1980's (Mowshowitz 1994), though it did not receive much academic attention until the early 1990s. Since this time, the concept of the virtual organization has become firmly entrenched in the literature and in the minds of researchers and business professionals.

Many definitions of the virtual organization, especially those early definitions, showed some tendencies towards technological determination. These definitions assumed that because the technology was available, there would be no more "traditional" companies in the future (i.e. (Rahman and Bhattachryya 2002)). All products and services would be developed and delivered by joining unrelated entities together to use their specialized skills. These temporary organizations would stay together long enough to accomplish the task and then disband. This type of organization would, according to this line of thinking, completely replace the "old" form as individuals and organizations realized the enormous efficiencies to be gained (Walter 2000; Rahman and Bhattachryya 2002).

While not all of the definitions had these tendencies towards technological determinism, some had a tendency to create narrow definitions of a virtual organization (i.e. (Walter 2000)). A good example of a narrow definition comes from Travica (1997): "VO's (virtual

organizations) refers to a new organizational form characterized by a temporary or permanent collection of geographically dispersed individuals, groups or organization departments not belonging to the same organization – or entire organizations, that are dependent on electronic communication for carrying out their production process" (Travica 1998). While this definition does not carry any type of technological determinism, it is a very narrow definition, and a reasonable example of a number of others. This does not cover any number of possible permutations of virtuality that organizations are exploring that have been categorized as virtual by other publications.

Other definitions tended to create overly broad categories, such that virtually any large multinational corporation would be defined as a virtual organization. For example, Rahman and Bhattachryya defined a virtual organization as "an organization distributed geographically and whose work is coordinated through electronic communication" (Rahman and Bhattachryya 2002). There are a number of broad definitions of the virtual organization (Chutchian-Ferranti 1999; Kishor and McLean 2002; Zhuge, Chen et al. 2002), which may have contributed to research moving away from categorizing the virtual organization as a single, definable thing, and lead to it being classified more as a movement.

For example, defining the virtual organization as an architecture, rather than as a specific organizational type (Venkatraman and Henderson 1998) moves us away from the notion of a virtual organization as a single specific thing. While this provides a useful abstraction from overly narrow definitions, it also makes it difficult to talk about a single type of virtual organization, or what theories or management methods could be used at a given organization. While many VO's are unique, and make use of different aspects of virtuality, it seems likely that there would be some characteristics that would link them and enable some cross study.

Contributing to this line of abstracting the virtual organization, the virtual organization was introduced as a theory, rather than as a specific definition. In a recent book: "We refer to it variously as a paradigm or principle to emphasize the lack of any specific organizational form attaching to it." (Mowshowitz 2002) While the concepts and broad definition presented in this work can encompass the many permutations of the virtual organization, its very flexibility makes it difficult to apply in research.

While one stream in the research on virtual organizations was moving towards defining the VO as a paradigm or framework, another was exploring the concept that companies exist along a continuum of virtuality (Goldman, Nagel et al. 1995; Hoffman, Novak et al. 1995; Burn and Ash 2000). The concept that organizations can be more or less virtual has been introduced in several papers (Venkatraman and Henderson 1998; Panteli and Dibben 2001). There have been several approaches to this, but none have provided very clear definitions of how to measure the virtuality of the organization. While these articles agree that the organization can adopt many points along a line, they are still all classified as a virtual organization. This also causes some problems, as there will clearly be different challenges for organizations located at different points along the "virtuality curve".

While research and interest in virtual organizations, and in making organizations more virtual, continues, little has been done to settle on a set of terms for the virtual organization. In fact, changes in the availability of skilled labor in a number of markets around the world has opened up new areas for research and practice in the area of virtual organizations as more organizations experiment with various ways of achieving virtuality.

Regardless of the definition used, the term is used frequently in both the business and academic press. This is due to the enormous implications of turning into a virtual organization (Koch 2000; Coates 2001; Staples 2001). Many articles have noted the potential implications for the firm (Venkatraman and Henderson 1998; Markus, Manville et al. 2000), the employees (Parus 1999; Koch 2000; Coates 2001; Ariss, Nykodym et al. 2002) and society at large for the changes that these organizations are currently undergoing. The sheer implications of this new organizational form demand a great deal of research, but how does this research fit together? Do the theories examined in these various articles fit together? Can the findings from one article looking at the VO be applied to another, or only in certain circumstances?

This confusion calls for a clearer structure in which to discuss the virtual organization. It is clear that there is not a simple, concise definition that will both encompass the many potential forms for the organizations and allow

the level of specificity required by the academic community to perform the type of research that must be completed to understand this phenomenon. What can be done to reconcile these various definitions?

## 3. DEFINITIONAL FRAMEWORK

While there are many different definitions for the virtual organization, several concepts are consistent across them. Specifically, the concepts of geographical dispersion, duration, ownership of resources, level of control over the organization and the level of electronic communication appear with great frequency in the discussion of virtual organizations. Each of these concepts is explored in turn, and then applied to the framework proposed in this paper.

It is generally agreed that the virtual organization is more widely distributed geographically than the traditional organization. While the level of dispersion is not defined (i.e. from Dallas to Ft. Worth, or from Chicago to Mumbai), the idea that the resources required for the production of goods or services are spread out in a virtual organization is broadly used. The geographical distribution of the organization adds certain challenges that "traditional" organization might not face. These challenges would include distribution of work across multiple time zones and cultures (Hughes, O'Brien et al. 2001).

Next, duration is a consideration for many of the definitions of the virtual organization. In some of the more radical definitions of the VO, groups come together for short periods of time, perform a task and then disperse (Byrne 1993; Katzy 1998). This can be very common when looking at temporary partnerships formed by organizations (Malhotra, Majchrzak et al. 2001). Duration is also consideration for the study of outsourcing – the length of time for the contract is certainly a factor for these types of arrangements.

It is also common for definitions of virtual organizations to state or imply that the organizations have a lower level of ownership of resources than is typical for the traditional view of the organization. One example of this would be outsourced manufacturing (Ariss, Nykodym et al. 2002). The concept of ownership also encompasses the notion of control – organizations that own the resources, more clearly have control over them than those who have outsourced these items to another organization. In the case of the open source software movement, there is no central control over the organization, and there is no ownership of the "organization" that is writing the software (Markus, Manville et al. 2000). In fact, the term organization is used very loosely here, as it is really an assembly of individuals with a common interest and skill set who work together to achieve a common goal – the very image of the exclusive definitions mentioned earlier in the paper.

The level of control exhibited by a virtual organization does help to define how virtual it is, but it seems that this concept could be usefully combined with that of ownership of the resources. It would be reasonable to expect that a company, which owns or employs the means of production, would have a greater level of centralized control over them than an organization which did not own or employ them.

The level of electronic communication is assumed to be high in virtual organizations, because it is this technology that first enabled the organizational form (Drucker 1998; Venkatraman and Henderson 1998; Mathias 1999). However, especially early research in VO's stated that not every organization will use the same level of electronic communication, because not every organization is as virtual as every other. While electronic communication is used frequently in the definitions, the majority of organizations use electronic communication today. Thus, this does not seem to be a good measure of the "virtual" organization.

In order to relate the various definitions to one another, this study has constructed a framework using the factors discussed above. For this framework, the concepts of Ownership, Time and Geographic Dispersion are used. By combining these three concepts, the framework presented in figure 1 (see Appendix 1) can be used to associate the various articles written on VOs and relate them to one another. By placing each concept along a continuum, we allow for varying degrees of virtuality along multiple dimensions. We also arrive at natural dividing lines between different types of virtuality by looking at the eight sectors formed by the three dimensional representation of the framework.

This framework provides a method to relate both the definitions that have been presented in the literature, and to relate the various studies that have been performed on VOs. This is not intended to be a comprehensive list all of the theories that apply to each sector, but rather a

starting point. Likewise, this is not intended to be a comprehensive list of organizational forms, but it does provide some examples of what could be expected within each of these sectors.

**Sector 1:**

High Dispersion, High Ownership, Long Duration

This could apply to any traditional multinational organization. They are highly dispersed, own their plants, and frequently use electronic communication as the only means of communication. An enormous amount of research has taken place in this sector in both Management and Information Systems. Some examples of this would include major auto makers like General Motors and Ford. Both are headquartered in the United States, but both sell cars on six continents under various brands and have for a long time.

**Sector 2:**

High Dispersion, Low Ownership, Long Duration

This could be an example of a company that has off-shored some of its operations. It is highly dispersed, does not own the operations and uses electronic communications extensively. Examples could include Dell and Apple, which have both outsourced their manufacturing. Dell could be an even better example, based on the number of operations they have outsourced. The open source movement (i.e. Linux) could also fall within this category (Markus, Manville et al. 2000). This sector would also encompass those more radical definitions of the VO (i.e. (Hughes, O'Brien et al. 2001)).

**Sector 3:**

High Dispersion, Low Ownership, Short Duration

Some of the definitions used for short term VOs could be applied here. For instance, creating a short term VO to accomplish a single task, after which it is dispersed (Byrne 1993; Hughes, O'Brien et al. 2001). Certainly, companies do form relationships like this to seek out specific business opportunities.

**Sector 4:**

High Dispersion, High Ownership, Short Duration

It is hard to imagine a good example for this particular sector. A highly dispersed organization, that is centrally owned/controlled, but that doesn't last long. This sounds more like a failed business than a VO, but by combining these factors, it is certainly possible to create a sector that would be unlikely to be populated. This could also be a model for a centrally controlled organization that is widespread, but with a set purpose that expires at a particular time. Perhaps the organizing committee for an Olympic bid would fall under this sector – a group with a highly centralized structure for ownership, a set time limit for its duration, but one that could be spread across a wide area.

**Sector 5:**

Low Dispersion, High Ownership, Short Duration

This sector could be used to look at the more recent trend towards "near shoring" in outsourcing. That is, the practice of outsourcing certain operations, but doing it to companies that are geographically close to headquarters, rather than overseas. The difference for this sector being that they have "near shored" to a wholly owned subsidiary of the company, rather than an outside agency.

**Sector 6:**

Low Dispersion, Low Ownership, Short Duration

This could be an example of a company that has temporarily "near shored" its operations, possibly even outsourcing them to a company locally. This has been occurring with greater frequency, especially in Europe. This sector shares some properties with sector 2, but would not be as likely to have some of the problems with cultural norms and time zones that organizations in sector 2 would.

**Sector 7:**

Low Dispersion, Low Ownership, Long Duration

This would be an example of a long term, near shoring arrangement for an organization. This could also be applied to some more traditional supplier relationships in manufacturing – the manufacturing of certain components is contracted out to another company in the area for an extended period of time to save the company the problems associated with making that particular part.

**Sector 8:**

Low Dispersion, High Ownership, Long Duration

This would be an example of a small town operation. They have very few locations, and own all of the operations. Of course, even this business model would be challenged by the fact that many suppliers now have their order entry systems on line and could be requiring their

customers to use that means of communicating with them. Organizations like this one could still benefit from some level of "virtualization" by tying into their suppliers electronically, thus using them as virtual warehouses, rather than keeping all of the required stock on hand.

Many of the definitions currently in the literature are good for pure VO's, or work well at a high level. However, narrow definitions leave us to conclude the virtual organization is a rare beast indeed, while high level definitions leave a great deal open to interpretation. By setting up a framework represented by a three dimensional model, this paper helps establish some boundaries that can be recognized when talking about Virtual Organizations, and provides a way to classify and compare the research that has taken place under the varied definition of VO.

While a broad definition of a VO (like those given in some of the literature) would allow a company to fall into any sector, looking at the factors presented in this framework would enable the researcher to restrict the organization to a single area. Doing so would allow the researcher to determine what theories might apply to companies within those sectors or help companies trying to move between them and to determine what strategies should be employed and what skills will need to be developed to be successful in these endeavors.

## 4. FUTURE WORK

An area for future work in this area will be the development of reliable measures for each of the axes presented in the framework. This would allow for an easy comparison of results across multiple studies and would also define what the break points are for each axis in the framework. While work has been done on each of these measures, it is beyond the scope of this paper to try to integrate them into a unified whole.

Examining which theories will hold in each of these sectors is also a rich area for future study. While there is certainly a great deal of research that could be classified as belonging to one sector or another, determining which theories can go between these would be a worthwhile endeavor.

## 5. CONCLUSIONS

In this paper, the past literature on Virtual Organizations has been briefly reviewed and an operational framework for future research in the area has been presented. The purpose of this paper was not to create another definition of what a virtual organization can be, but rather to provide a framework on which to build future research and to provide possible boundary conditions for the various theories and definitions of the virtual organization.

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## Appendix 1 – Figure 1

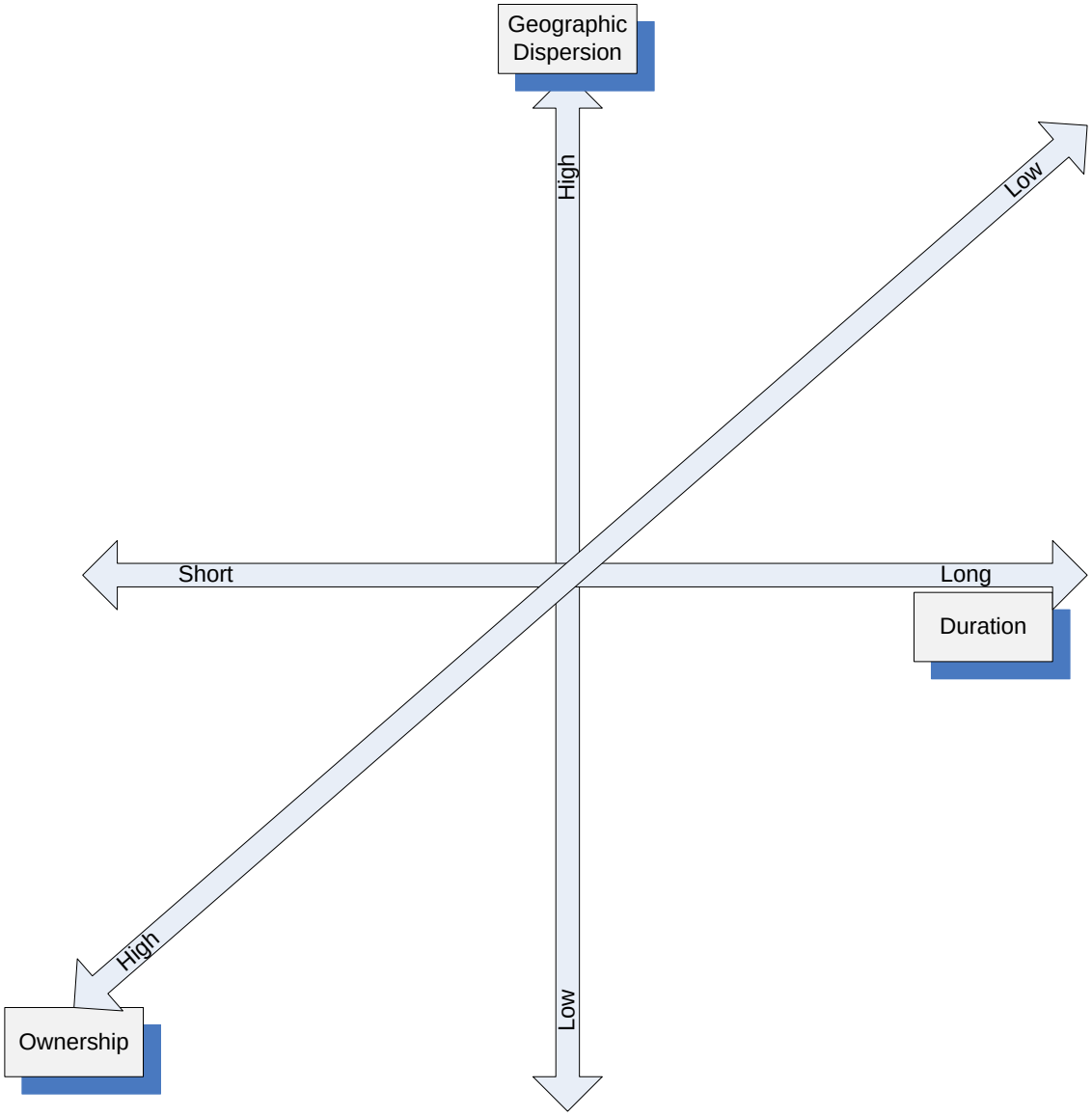


**FIGURE ONE** – A Framework for the research of Virtual Organizations

# The Potential Reality of Service-Oriented Architecture (SOA) in a Cloud Computing Strategy

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## Abstract

The constraints of the current economy continue to affect business firms investing in information systems. This paper analyzes the extent of implemented initiatives in Service-Oriented Architecture (SOA) that may be impacted by limited investment in technology. Derived from an earlier study of SOA published in 2008, the findings from a literature survey and a case study in the current paper disclose that few firms identified in the earlier study have advanced noticeably to enterprise integrated and matured processes enabled by SOA, though the bulk of the firms continue investment in projects of SOA. The implications however indicate that continued investment in the projects may facilitate a foundation for initiatives in cloud computing. This paper might benefit educators considering expansion of SOA in curricula of information systems, and it may help practitioners considering increased investment in SOA as a potential strategy to be positioned to take advantage of cloud computing.

**Keywords:** cloud computing, program management methodology, service-oriented architecture (SOA), service-oriented computing (SOC), service-oriented enterprise (SOE)

### 1. BACKGROUND AND DEFINITION

Service-Oriented Architecture (SOA) is currently defined in the literature as an enabled framework of technology:

"[that] … aims to enhance … agility and cost-effectiveness of an enterprise while [lessening] the burden of Information Technology on the overall organization" (Erl, 2009) and

"that allows all interested systems, [internal and external to a business firm], to expose and access defined services, and information bound to those services, that may be further abstracted to process layers and composite applications for developing [solutions] (Linthicum, 2010, p. 5)".

Essentially SOA, or Service-Oriented Computing (SOC), is focused on the notion of services as a factor for development of software solutions (Brogi, Corfini and Popescu, 2008). SOA furnishes benefits for firms investing in flexibly improved business processes and solutions, as frequently indicated in practitioner (Smith, 2008 and Watson, October, 2008) and prior scholarly literature (Vom Brocke, 2007). The goal of firms investing in SOA is to be a fully deployed Service-Oriented Enterprise (SOE) in integrating

internal and external processes and services – processes of the firms as services (Gens, 2009) – in larger and matured business unit–to–business unit and internal firm–to–external firm "on demand" solutions, based on a business strategy (Lawler, Benedict, Howell-Barber and Joseph, 2009). Most firms in industry cite deployed, developmental, experimental or anticipated investment in SOA, as indicated in Figure 1 of the Appendix, attesting to an apparent inevitability of SOA as a strategy. This inevitability may not be a reality.

The number of business firms deploying or further deploying SOA is indicated in the literature to be less in 2008-2009 than in 2007 (Taft, 2008). Less investment in SOA is indicated as an effect of the downturn in the economy (Thibodeau, 2008, p. 12) – even in financial firms that have historically invested in new methodology and technology (Sausner, 2009). Though more than half of firms investing in SOA have had anticipated or more than expected benefits, less than half have had less than expected benefits or have not deployed it on operational systems, as indicated in Figure 2. Initiatives in SOA are costly investments. Benefits of SOA are frequently hyped by technology firms, instead of the complexity of deploying SOE into the infrastructure of business firms.

The inevitability of SOA is countered by a perceived reality that SOA may be dead as a proposition:

"SOA met its demise on January 1, 2009 … by the catastrophic impact of the [economy] … a failed experiment – at least for most [business firms] … except in rare situations SOA failed to deliver promised benefits … systems are no better than before [SOA] … [firms have] to accept reality ... [they have to remove it] from [their] vocabulary" (Manes, 2009).

Others contend that SOA may fade into software-as-a-service (SaaS) (McKendrick, 2008), or into cloud computing. The condition of SOA in 2009 may not be as dire however as presented by pundits, and may be myopic (Woodhull, 2009), especially as they might better inform readers of the bona fide benefits of SOA in improving business processes in a business strategy (Linthicum, 2009), if not in an eventual cloud computing strategy.

Firms are investing reasonably in services of SOA as a methodology for the benefits of improving processes in a business strategy (Watson, December, 2008), as further indicated in plans for 2009 in Figure 3 (D'Auria, 2009). The problem of SOA is investing in initiatives on a path of internal and external business unit and firm processes that leads to an SOE, or SOEA - Service-Oriented Enterprise Architecture (Brooks, 2009), – in firms, a path that integrates processes as services in more business units on more projects with more technical and business staff, but on a path of a business strategy, not a technology strategy (Lawler, Raggad and Howell-Barber, 2008). SOA is a costly and exhausting program, but it enables foundation of a platform of "on demand" services for cloud computing (Krill, 2009), a perceived cost savings strategy, which might inherently be the inevitability of an SOA strategy (Linthicum, 2008). Cloud computing is defined in the literature as below:

"any resource [of Information Technology] … including application services … that exists outside of the firewall that may be leveraged by enterprise Information Technology over the Internet;" (Linthicum, 2010, p. 7)

"… a strategic technology." (Thibodeau, 2008, p. 14)

Cloud computing is also described in groups of infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS) (Yachin and Patterson, 2009), in Table 1 of the Appendix. SOE might be helpful in facilitating the formation of a platform of internal or external processes as remote services, the interfaces to the platform that extend into cloud computing resources, and the standards. Study of firms that are effectively maturing to SOE and enabling cloud computing might benefit practitioners considering further investment in SOA, as a strategy to take advantage of the movement to cloud computing technology, if not educators considering further inclusion of SOA in curricula of information systems.

## 2. INTRODUCTION TO STUDY

In this new study, the authors analyze business firms that have invested in SOA as first movers in 2005 – 2007 and matured on a path to SOE that integrates processes as services in a business strategy. This study is based on an earlier study of the firms published by the authors (Lawler and Howell-Barber, 2008, pp. 61-170). Findings from the earlier study indicated that business firms that led initiatives in SOA with business criteria had more benefits in effective processes from SOA than firms that

led projects with purely technical dimensions (Lawler and Howell-Barber, 2008, pp. 171-180), confirming an even earlier study of other firms on services (Lawler, Anderson, Howell-Barber, Hill, Javed and Li, 2005). Findings from the 2008 study further indicated that business firms had more benefits from SOA if the initiatives were not 'low hanging fruit" projects but solutions of strategy. Management of SOA as a business strategy was indicated in the studies to subordinate technology hyped by technology firms to the practitioner vision of SOE. The management of initiatives on a path to SOE was analyzed by a program management methodology applied in the studies that might even facilitate implementation of a cloud computing strategy.

The program management methodology is defined as a disciplined Methodology for Enabling Service-Oriented Architecture (MESOA) (Lawler and Howell-Barber, 2008, p. 27-59), akin to business process management (BPM) in analyzing and continually enhancing fundamental activities of the operation of business firms (Wisner and Stanley, 2008). This methodology is complimentary to project management methodologies already established in firms and is both technology firm and technology neutral. It is depicted in Figure 4, and described in frameworks of best practices of governance, communication, product realization, project management, architecture, data management, service management, human resource management and post implementation, for business, corporate and technical staff on initiatives or projects of SOA, in Table 2. The frameworks are coupled or related steps for the staff in managing projects of SOA. These steps are top-down from business strategy and bottom-up from technology strategy, favorable in mitigating the risks of SOA. The frameworks of the methodology evolve as SOA matures in iterative phasing and incremental movement towards SOE, in a manner similar to established methodologies in the literature (Tiba, Wang, Ramanujam and Capretz, 2009).

The program management methodology was applied in the 2005-2007 period of the earlier study (Lawler and Howell-Barber, 2008, pp. 61-170) in an economy not as constrained as in 2009-2010. The benefits of the new study will be in evaluating the progress or non-progress of initiatives of SOA in a constrained economy and furnishing guidance, inasmuch as continued investment in progression of SOA might facilitate later opportunities (Walker, 2009). Investment in projects of SOA may be crucial in progression of services towards SOE that might facilitate a foundation for a cloud computing strategy if business firms follow best practices of SOA. Practitioners may be hesitant however about further investment in SOA (Currier, 2009), because of complexity of functionality or because of benefits not fast enough for funding justification, though SOA leads to savings (Castro-Leon, 2008). Educators may be hesitant about inclusion of SOA as a discipline or even as a foundation for cloud computing in the curricula of information systems if firms do not continue investment in it. The reality or non-reality of SOA is important to study, and the results of this study will furnish input to educators and practitioners.

## 3. FOCUS OF STUDY

The focus of this study is to analyze the extent of implemented initiatives of SOA that might be impacted by limited investment in technology, due to the more constraining economy of 2009-2010. The initiatives are analyzed for maturity of SOA from the aforementioned frameworks of the program management methodology in Table 1 that were developed in the earlier published research study of the authors (Lawler and Howell-Barber, 2008, pp. 27-59). The frameworks of the methodology are applied to new initiatives and to new levels of maturity of SOA in the business firms identified in the initial study of SOA. Such firms were innovators of SOA during the less constraining economy of 2005-2007 and were a model in that study. This study analyzes evidence of initiatives of cloud computing concurrent with the analysis of SOA, but the focus is on the investment progression or non-progression of SOA in the current economy.

## 4. RESEARCH METHODOLOGY

The research methodology of the study consisted of a literature scan of 15 Fortune 10 – 1000 business firms, in the automobile (1), banking (3), energy (1), health (1), insurance (2), manufacturing (1), technology (2), telecommunications (2), training (1) and travel and leisure (1) industries, that were analyzed for current initiatives in SOA during the more constraining economy of 2009.

The firms of the study were identified as innovators in the initial study of the authors (Lawler and Howell-Barber, 2008, pp. 61-170). Each of the 15 firms was analyzed from a

practitioner publication survey in March – June 2009 by a graduate student in an Independent Project Study of Service Oriented Architecture (SOA), at the Seidenberg School of Computer Science and Information Systems of Pace University. This student was under the direction of the first author of this study. The initiatives of the firms were analyzed collectively by application of the frameworks of governance, communication, product realization, project management, architecture, data management, service management, human resource management, and post implementation of the program management methodology described in the earlier section. The frameworks were evaluated on a four-point scale of high enablement (3), intermediate enablement (2), low enablement (1), and no enablement (0) of SOA.

The methodology also consisted of a case study of 3 of the 15 firms. Each of the 3 firms was analyzed individually in May-June 2009 and October-November 2009 by an experienced industry practitioner, under the direction of the first author. The initiatives of the 3 firms were analyzed internally by application of the aforementioned frameworks of the methodology and evaluated on the aforementioned scale, separate from the survey. The evolution of the new initiatives of the 15 firms to new levels of maturity of SOA were concurrently evaluated in summary by the practitioner for deployment of Web services based on SOA; deployment of services, integration of process and services architecture and restructuring of organizations and staff; and deployment of services based on SOE, in comparative evaluation to the earlier study.

The methodology included evaluation in summary of the 15 firms for evidence of cloud computing initiatives in groups of infrastructure as a service (IasS), platform as a service (PaaS), and software as a service (Saas) (Yachin and Patterson, 2009), which was performed by the first author from the accumulated documentation on the 15 firms.

Finally, the research methodology of the study further included descriptive statistical interpretation by the second author of this study.

## 5. ANALYSIS AND DISCUSSION OF FINDINGS

The analysis of the data from the literature scan of the 15 business firms in 2009 disclosed that few of the firms migrated noticeably in maturity of SOA since the earlier study of 2005 – 2007 of SOA, as is indicated in Table 3 of the Appendix.

Firms 1, 2, 3, 4 and 9 advanced from low to intermediate enablement of maturity of SOA, but firms 5, 6, 7, 8, 10, 11, 12, 13, 14 and 15 continued to be low or intermediate in enablement of SOA. No firm advanced to full or highest enablement of maturity of SOE (Service-Oriented Enterprise) from the limited investment of SOA.

The analysis of the data from the detailed case study of 3 of the 15 firms in 2009 was consistent essentially from the findings of the literature scan, as indicated in Table 4. Firms 1 and 3 advanced from low to intermediate enablement of SOA. Firm 7 continued to be intermediate in enablement of SOA. Firms 1, 3 and 7 indicated that due to the economy investment was limited to business benefits that might be derived on projects of SOA. Forecasts for investment on new projects in 2010 were indicated to be low.

(Figure 6 of the Appendix indicates levels of maturity of SOA from Web services to SOE.)

The analysis of the data from the literature scan of the frameworks of the 15 business firms disclosed improvement but not noticeably into high maturity of SOA, as indicated in Table 5.

Communication, service management and post implementation advanced from low to intermediate enablement of SOA; governance, product realization, project management, architecture and data management continued to be intermediate or low; and human resource management declined from intermediate to low enablement. No framework moved to full or highest enablement of maturity of SOA.

The analysis of the data from the detailed case study of the frameworks of Firms 1, 3 and 7 were consistent with the findings of the literature scan.

The final analysis of the data from the literature scan of the 15 firms and the case study of the 3 firms disclosed essentially low investment in cloud computing initiatives during the 2009 study, as indicated in Table 6.

Firms 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 14 and 15 in the literature scan were low or non-existent in indication in investment in cloud computing projects. Firms 4 and 13 in the scan were intermediate in investment migration, and Firms 1, 3 and 7 in the detailed case study were

low or non-existent in investment on the projects, as in the literature scan. Firms 1, 3 and 7 indicated that investment was low or non-existent on the cloud computing projects due to the economy and to hesitancy in the technology, but project managers in the firms perceived existing investment in SOA as a favorable foundation for future cloud computing projects. Forecasts for new projects in 2010 were undetermined or low.

(Figure 7 indicates levels of maturity of cloud computing in the firms.)

In summary, the analysis is disclosing that few of the business firms have advanced significantly to a high maturity of an SOE. Encouraging however is the finding that the other firms in the study have continued disciplined expenditure of investment in projects of SOA on a path potentially to SOE, albeit at intermediate to low levels. They have continued enablement of the projects in the frameworks of program management methodology. This investment may facilitate migration to cloud computing once the firms decide to move to the cloud.

## 6. IMPLICATIONS OF STUDY

*Expenditure for SOA was clearly affected by the constraining economy. Few of the business firms in the current study of 2009-2010 migrated SOA into SOE in a significant manner since the earlier study of 2005-2007 of SOA*. They focused on less important initiatives that limited progression to enterprise integrated and matured processes of an SOE. However, they focused on projects having discernable business benefits of SOA (SOA Manifesto, 2009) so that these projects might enable an incremental progressive strategy towards SOE, not sacrificing the strategy to short-term goals (MacSweeney, 2009). Though expenditures for technology in firms in industry are limiting investment in larger projects of SOA (Banerji, 2009), firms in the current study were noted to be on the path of an SOE strategy but not significantly.

*Initiatives of the firms in SOA were clearly aligned with business goals*. All of the chief information officers (CIO) in the firms of the study were apparently cognizant of investment in SOA as a business strategy. They collaborated generally on a portfolio of projects of SOA with executive vice presidents who were frequently executive sponsors of SOA. Executive sponsorship is indicated in the literature to be critical in a progressive strategy (Kavis, 2008). Though investment in SOA was limiting the number of projects, the leadership was noted to be cautious that projects contributed to a bona fide business strategy.

*Projects of SOA were clearly disciplined in the firms by evidence of the frameworks of the program management methodology of the study*. Frameworks of governance and service management enabled especially a progressive SOA strategy. Governance is indicated in the literature to be a key ingredient in an SOA strategy (Berry and Van Alst, 2009, Lundquist, 2009 and Worthington, 2009). Service standards were a key ingredient in the reusability of services in the strategy. The management of the projects by the methodology was noted to be critical in ensuring SOA structure.

*Several of the firms in the study initiated cloud computing projects that were enabled by an earlier foundation of service orientation*. Further investment may escalate progression to integrated processes of SOE that might facilitate cloud computing strategy. Though practitioners in the firms in the study might be hesitant about further investment in SOA (Preston, 2008), they might increase investment as they learn of, if not realize, the cost savings of a cloud computing strategy that takes advantage of SOA. The interdependence of cloud computing and SOA was clearly noted to be a feature of the few cloud computing projects that were progressing seriously in the several firms. This was noted to be a proposition of value.

*The reality of SOA was clearly evident in the firms of the new study despite constraining investment*. Schools of computer science and information systems might be comforted in integrating the methodology of SOA into curricula. They might consider integrating cloud computing and SOA to be current with enterprise architecture methodology (Nash, 2009). They might inform students of enterprise architect positions (Gibson, 2008) required for shifting to SOE that might facilitate a cloud computing strategy. Those in schools of information systems might instruct students in methodologies that matter in SOA strategy.

## 7. LIMITATIONS AND OPPORTUNITIES IN RESEARCH

The findings of the current new study were derived from an essentially small number of firms in industry, limiting extrapolation to a larger population. The firms were generally

innovators in SOA identified in the initial study (Lawler and Howell-Barber, 2008, pp. 61-170), and not included in the sample were non-innovators or subsequent innovators since the studies. The investigation of the initiatives of SOA was subject to the confidentiality limitations of the organizations.

The next research steps will be in increasing the number of firms in the sample and the scope of firms investing not only in SOA but also and especially in cloud computing methodology and technology. These steps will be initiated in 2010-2012 in a continued study of SOA.

## 8. CONCLUSION

The paper analyzed initiatives of SOA affected by the constraining economy in 2009-2010. The findings indicated that few of the business firms in the model of the paper have advanced significantly to the highest of integrated and matured processes of an SOE. However, the bulk of the firms in the study have continued investment in SOA, although less than in the economy of 2005-2007. The paper in fact indicated that investment is facilitating implementation of cloud computing initiatives that might contribute to cost savings not perceived in initial investment in projects of SOA. Though further research will continue on the reality of SOA, the findings of the recent study encourage instructors to continue including SOA in the curricula of information systems, and encourage manager practitioners to continue investing in SOA as they migrate to cloud computing initiatives.

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## APPENDIX

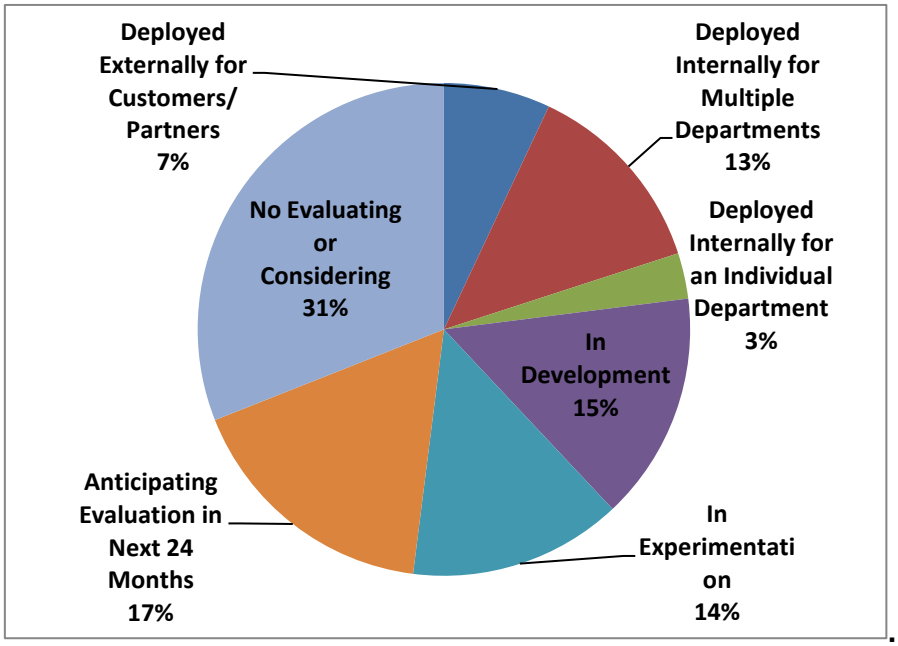


**Figure 1: Deployment of SOA**

Source: Smith (2009) "Trouble Ahead, Trouble Behind: Is SOA on Track for Recovery, or Has This Technology Been Permanently Derailed by the Economic Downturn?" Information Week, Information Week Analytics, State of SOA Survey, February 23, p. 28 [Adapted].

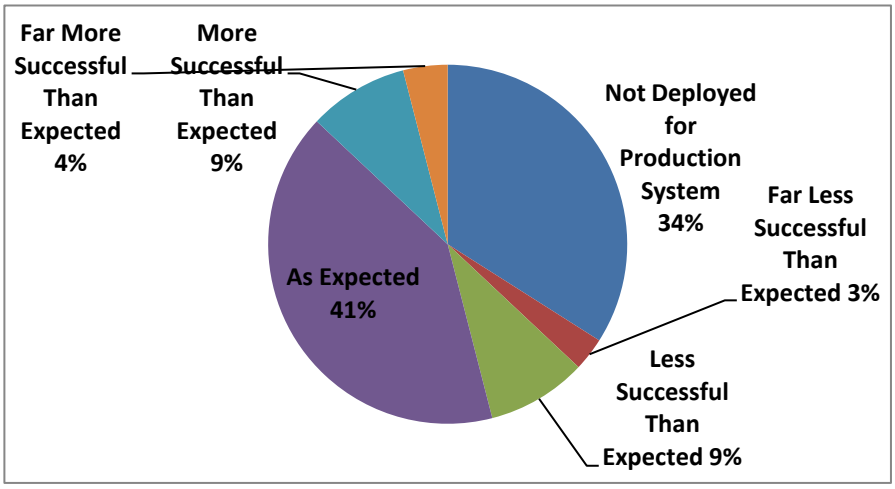


**Figure 2: Impact of SOA**

Source: Smith (2009) "Trouble Ahead, Trouble Behind: Is SOA on Track for Recovery, or Has This Technology Been Permanently Derailed by the Economic Downturn?" Information Week, Information Week Analytics, State of SOA Survey, February, p. 29 [Adapted].

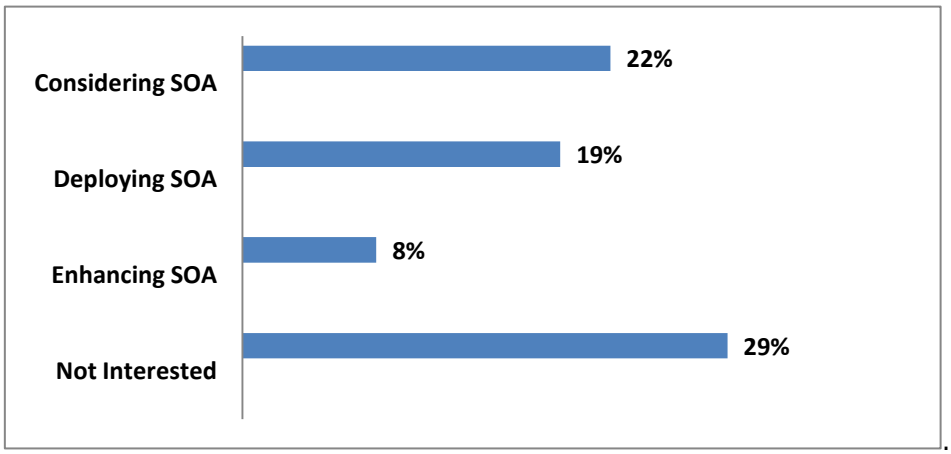


**Figure 3: Investment of SOA**

Source: D'Auria (2009) "Datapoints: SOA Intentions", CIO, CIO Research, February 1, p. 52 [Adapted].

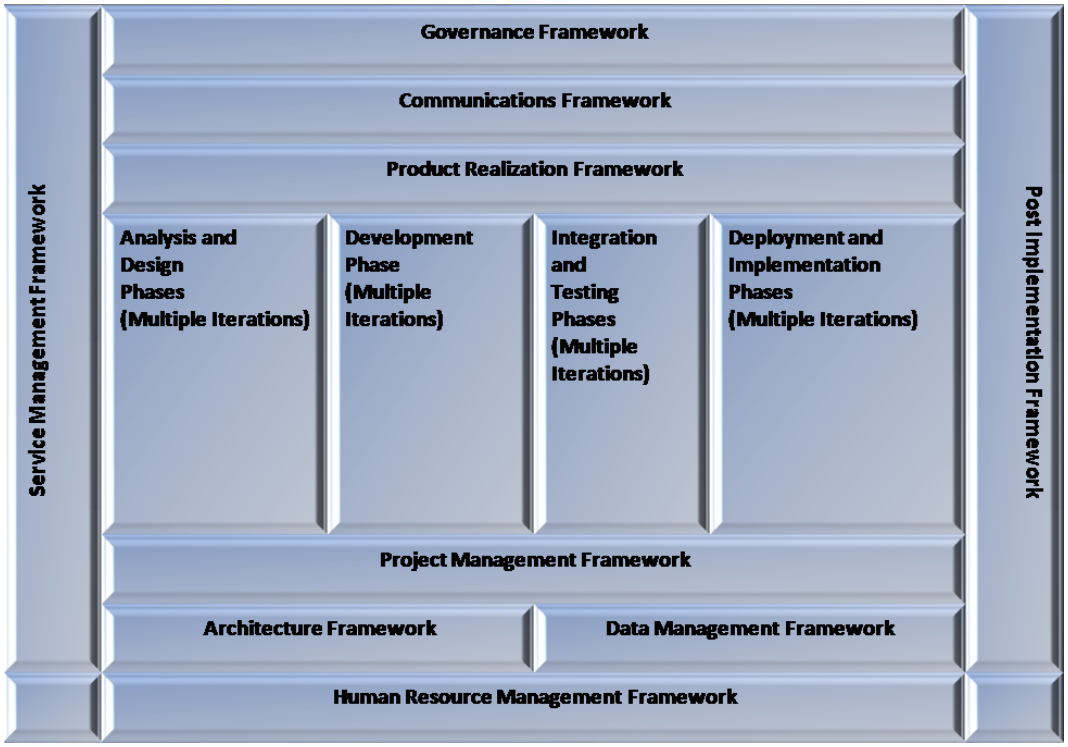


**Figure 4:**

Source: Lawler and Howell-Barber (2008) Service-Oriented Architecture: SOA Strategy, Methodology, and Technology. Taylor and Francis Group, Boca Raton, Florida, pp. 27-59.

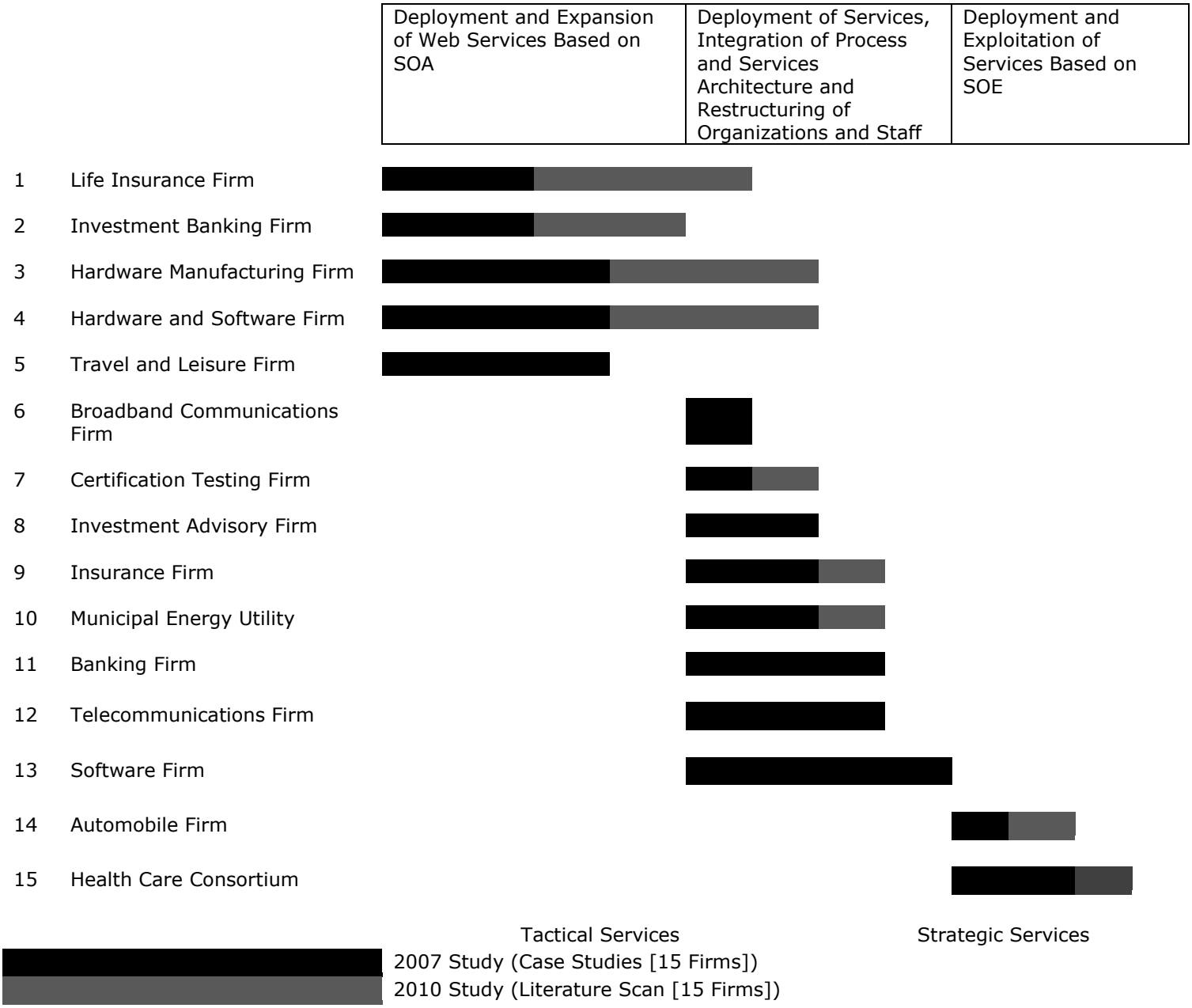


**Figure 5: Levels of Maturity of SOA in Firms of the 2010 and 2007 Studies**

Note: Figure 5 is an extrapolation of the findings in Table 3 as they affect Web services, deployment, integration and restructuring, and SOE, and is for illustrative purposes.

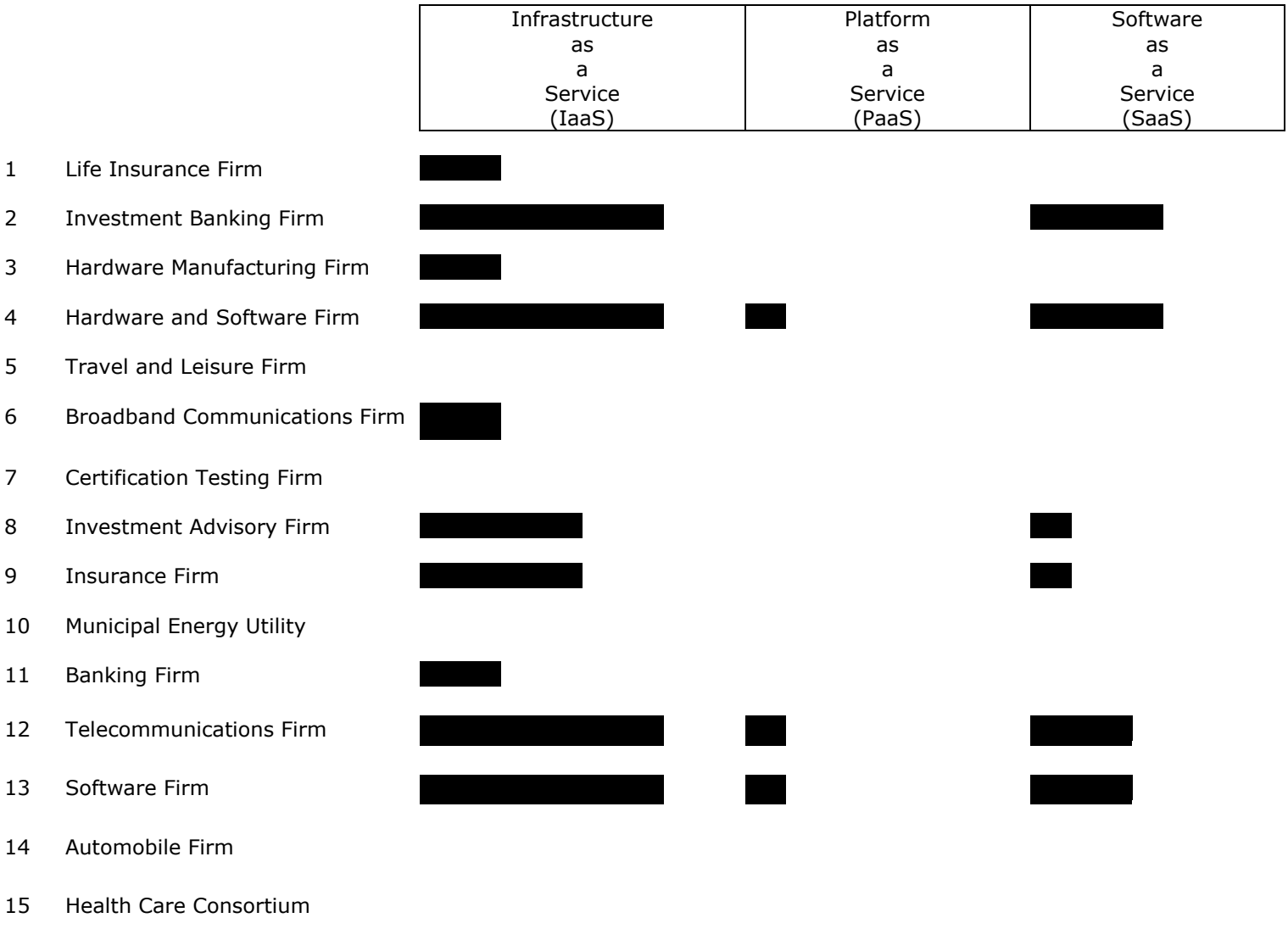


**Figure 6: Levels of Maturity of Cloud Computing in Firms of 2010 Study**

Note: Figure 6 is an extrapolation of the findings in Table 6 as they apply to IaaS, PaaS and Saas and is for illustrative purposes.

**Table 1: Cloud Computing Groups of Resources**

| Group | Definition |
|---|---|
| Infrastructure as a Service (IaaS) | Infrastructure Furnishing Services such as CPU, Networking and Storage for Business Firm (e.g. Verizon) |
| Platform as a Service (PaaS) | Platform Furnishing Services to Deploy, Host and Maintain Systems for Firm (e.g. Oracle) |
| Software as a Service (SaaS) | Software Furnishing Services to Host Network Systems Accessible to Clients of Firm on the Internet (e.g. Salesforce.Com) |

Source: Yachin and Patterson (2009) "Market & Analysis Overview: Cloud Computing." IDC, September, p. 1 [Adapted].

**Table 2: Frameworks of Program Management Methodology**

| Framework | Definition |
|---|---|
| Governance | Enables Alignment of Processes and Services with Business Strategy and Results in Evolution towards SOE |
| | Ensures Services Conform to Consistent Corporate SOA Strategy Supporting Business Strategy of Firm |
| | Facilitates Learning of Program Management Methodology |
| Communications | Enables Emphasis on Business Criticality of SOA of Business Firm, Articulated by Chief Information Officer (CIO), if Not Chief Executive Officer (CEO) |
| | Ensures Collaboration of Business and Technical Staff in Continued Plan on Endeavor, Coupled with Other Frameworks |
| Product Realization | Enables Analysis and Design, Development, Integration and Testing, and Deployment and Implementation of SOA and Is Core of Established Project Management Methodology |

| | |
|---|---|
| | Is Coupled with Other Frameworks and Ensures Focus of Projects Is on Business Processes to Be Evolved into SOA and Not on Technology |
| | Program to Be Realized May Be Implemented in Interlinked Iterations of Internal Department Application Projects to External Firm Process Integration Projects |
| | |
| Project Management | Enables Delivery of Projects of SOA |
| | Ensures Changes in Business Strategy Are Applied as Appropriate on Projects of SOA |
| | Ensures Processes and Services Are Functioning and Implemented as Planned in Strategy |
| Architecture | Enables Compliance of Business Processes with SOA Model |
| | Ensures Evolution from Conversion of Functions into Services, Creation of Component Services and Integration into Composite Services, Integration of Internal Applications, Internal Services and External Services, to On-Demand Services in a Gradual SOE |
| | Ensures Seamless Integration of Hardware and Software Conforming to Service Standards and Technology |
| Data Management | Enables Behaved SOA Data Services Not Disruptive of Applications of Firm |
| | Enables Implementation of Services, Based on Access, Availability, Breath and Accuracy of Data Already in Databases of Applications |
| | Ensures Consistency of Data |
| | |
| Service Management | Enables Continued Conformity and Coordination of Processes and Services to Business Strategy |

| | |
|---|---|
| | Is Coupled with Product Realization on New Projects of SOA and Ensures Requirements for New Processes and New Services, or Revisions to Them, Are Not Redundant with Existing Processes or Services |
| | Ensures Reusability of Services |
| Human Resource Management | Enables Identification of New and Revised Responsibilities and Roles of Business and Technical Staff on SOA |
| | Ensures Education of Business and Technical Staff on Change in Culture of Service Orientation, and Technical Staff on Technology of SOA, Is Furnished throughout Projects of SOA |
| Post Implementation | Enables Service and Process Life Cycle Tasks Following Product Realization |
| | Ensures Availability of Applications and Services and of Technologies, Tools and Utilities of SOA |
| | Is Formulated in Service Level Agreements (SLA) between Technology Department, Internal Business Departments and Business Units |

Source: Lawler and Howell-Barber (2008) Service-Oriented Architecture: SOA Strategy, Methodology, and Technology. Taylor and Francis Group, Boca Raton, Florida, pp. 27-59.

**Table 3: Literature Scan of Business Firms – SOA Summary**

| Firms | Names | 2009 Study | | 2005-2007 Study | |
|---|---|---|---|---|---|
| | | Mean | Standard Deviation | Mean | Standard Deviation |
| 1 | Life Insurance Firm | 2.22 | 0.83 | 1.44 | 1.24 |
| 2 | Investment Banking Firm | 2.22 | 0.83 | 1.56 | 1.51 |
| 3 | Hardware Manufacturing Firm | 2.11 | 0.78 | 1.56 | 0.88 |
| 4 | Hardware and Software Firm | 2.44 | 0.53 | 1.44 | 1.33 |
| 5 | Travel and Leisure Firm | 1.22 | 0.44 | 1.22 | 0.44 |
| 6 | Broadband Communications Firm | 1.89 | 0.60 | 1.44 | 1.01 |
| 7 | Certification Testing Firm | 2.33 | 1.00 | 2.00 | 0.87 |
| 8 | Investment Advisory Firm | 1.89 | 0.93 | 1.56 | 1.33 |
| 9 | Insurance Firm | 2.00 | 0.50 | 1.89 | 0.78 |
| 10 | Municipal Energy Utility | 1.67 | 0.71 | 1.22 | 0.97 |
| 11 | Banking Firm | 2.56 | 0.53 | 2.22 | 0.97 |
| 12 | Telecommunications Firm | 2.44 | 0.73 | 2.33 | 0.87 |
| 13 | Software Firm | 2.67 | 0.71 | 2.67 | 0.71 |
| 14 | Automobile Firm | 2.22 | 0.67 | 2.11 | 0.93 |
| 15 | Health Care Consortium | 2.33 | 0.50 | 2.11 | 0.78 |
| | | 2.15 | 0.69 | 1.79 | 0.99 |

Legend: High enablement of maturity (3), intermediate enablement of maturity (2), low enablement of maturity (1), and no enablement (0)

**Table 4: Case Study of Business Firms – SOA Summary**

| Firms | Names | 2009 Study | | 2005-2007 Study | |
|---|---|---|---|---|---|
| | | Mean | Standard Deviation | Mean | Standard Deviation |
| 1 | Life Insurance Firm | 2.11 | 0.60 | 1.44 | 1.24 |
| 3 | Hardware Manufacturing Firm | 2.33 | 0.50 | 1.56 | 0.88 |
| 7 | Certification Testing Firm | 2.22 | 0.83 | 2.00 | 0.87 |
| | | 2.22 | 0.64 | 1.79 | 0.97 |

**Table 5: Literature Scan of Business Firms – SOA Detail**

| Frameworks of SOA | 2009 Study | | 2005-2007 Study | |
|---|---|---|---|---|
| | Mean | Standard Deviation | Mean | Standard Deviation |
| Governance | 2.20 | 0.56 | 2.07 | 0.70 |
| Communication | 2.27 | 0.80 | 1.73 | 0.96 |
| Product Realization | 2.20 | 0.77 | 2.00 | 0.93 |
| Project Management | 1.93 | 0.59 | 1.00 | 1.00 |
| Architecture | 2.60 | 0.51 | 2.33 | 0.82 |
| Data Management | 1.87 | 0.92 | 1.67 | 1.11 |
| Service Management | 2.27 | 0.70 | 1.40 | 1.24 |
| Human Resource Management | 1.93 | 0.80 | 2.07 | 1.03 |
| Post Implementation | 2.07 | 0.96 | 1.80 | 1.15 |

**Table 6: Literature Scan and Case Study of Business Firms – Cloud Computing Summary**

| Firms | Names | Literature Scan | | Case Study | |
|---|---|---|---|---|---|
| | | 2009 Study | | 2009 Study | |
| | | Mean | Standard Deviation | Mean | Standard Deviation |
| 1 | Life Insurance Firm | 0.33 | 0.58 | 0.33 | 0.58 |
| 2 | Investment Banking Firm | 1.33 | 1.15 | | |
| 3 | Hardware Manufacturing Firm | 0.33 | 0.58 | 0.33 | 0.58 |
| 4 | Hardware and Software Firm | 2.00 | 0.00 | | |
| 5 | Travel and Leisure Firm | 0.00 | 0.00 | | |
| 6 | Broadband Communications Firm | 0.33 | 0.58 | | |
| 7 | Certification Testing Firm | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | Investment Advisory Firm | 0.67 | 0.58 | | |
| 9 | Insurance Firm | 0.67 | 0.58 | | |
| 10 | Municipal Energy Utility | 0.00 | 0.00 | | |
| 11 | Banking Firm | 0.33 | 0.58 | | |
| 12 | Telecommunications Firm | 1.33 | 0.58 | | |
| 13 | Software Firm | 2.00 | 0.00 | | |
| 14 | Automobile Firm | 0.00 | 0.00 | | |
| 15 | Health Care Consortium | 0.00 | 0.00 | | |
| | | 0.62 | 0.35 | | |